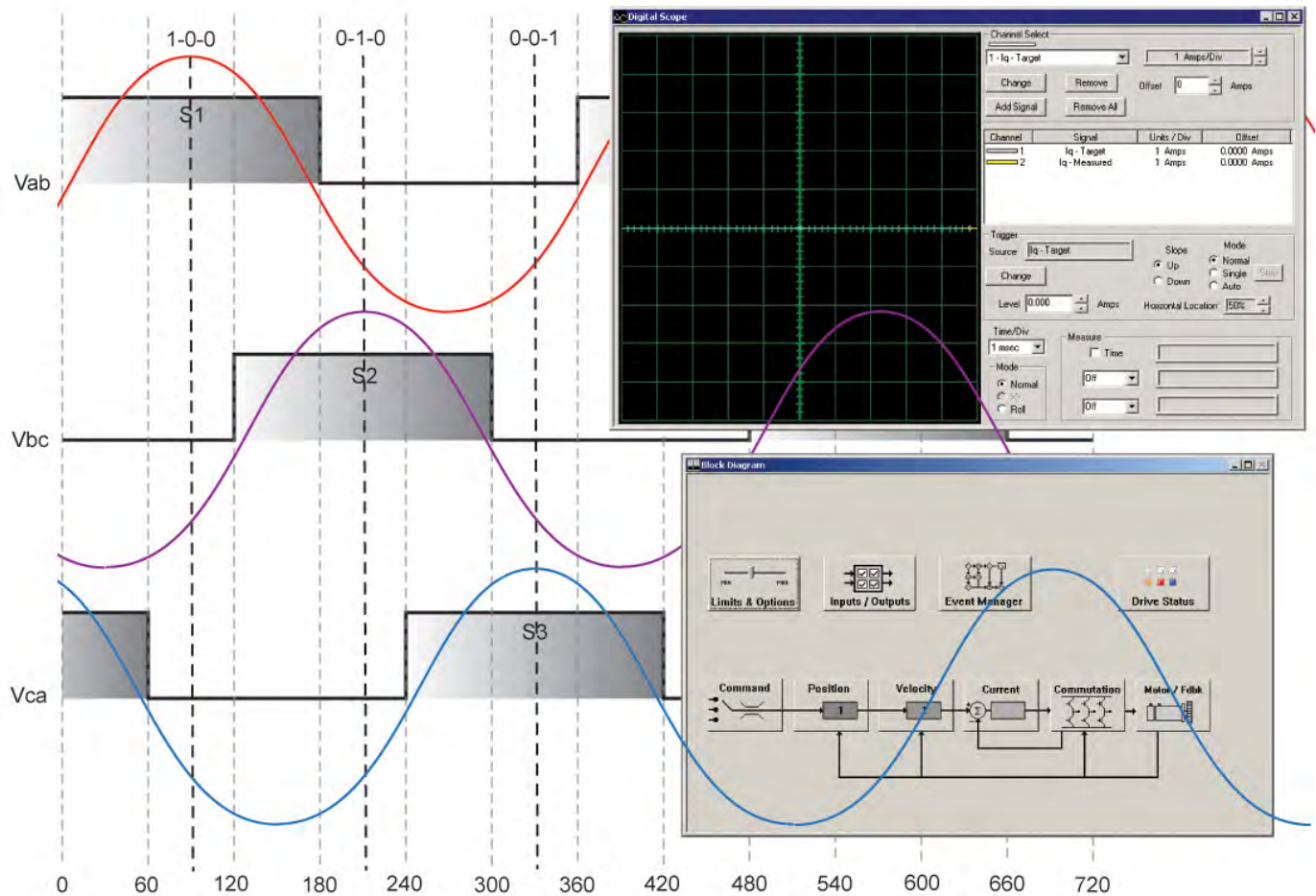




DriveWare™ 5.4

User Guide

Setup Software

Operator's Manual

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Preface

ADVANCED Motion Controls constantly strives to improve all of its products. We review the information in this document regularly and we welcome any suggestions for improvement. We reserve the right to modify equipment and documentation without prior notice.

For the latest revision of this manual, visit the company's website at www.a-m-c.com. Otherwise, contact the company directly at:

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General Safety



Notice

You must install and operate *ADVANCED* Motion Controls motion control equipment so that you meet all applicable safety requirements. Ensure that you identify the relevant standards and comply with them. Failure to do so may result in damage to equipment and personal injury.

Read this entire manual prior to attempting to install or operate the drive. Become familiar with practices and procedures that allow you to operate these drives safely and effectively. You are responsible for determining the suitability of this product for the intended application. *ADVANCED* Motion Controls is neither responsible nor liable for indirect or consequential damages resulting from the inappropriate use of this product.



Caution

High-performance motion control equipment can move rapidly with very high forces. Unexpected motion may occur especially during product commissioning. Keep clear of any operational machinery and never touch them while they are working.



Keep clear of enclosed units, motor terminals, and transformer terminals when power is applied to the equipment. Follow these safety guidelines:

- Always turn off the main power and allow sufficient time for complete discharge before making any connections to the drive.
- Make sure that the minimum inductance requirements are met. Pulse Width Modulated (PWM) amplifiers deliver a pulsed output that requires a minimum amount of load inductance for proper operation.
- Do not rotate the motor shaft without power. The motor acts as a generator and will charge up the power supply capacitors through the amplifier. Excessive speeds may cause over-voltage breakdown in the power output stage. Note that an amplifier having an internal power converter that operates from the high voltage supply will become operative.
- Do not short the motor leads at high motor speeds. When the motor is shorted, its own generated voltage may produce a current flow as high as 10 times the amplifier current. The short itself may not damage the amplifier but may damage the motor.
- Do not make any connections to any internal circuitry. Only connections to designated connectors are allowed.

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1 Introduction

This document provides instructions to use the setup software to connect to, set up and control digital servo drives.

These instructions walk you through the commissioning steps necessary to set drive limits, tune the current, velocity, and position control loops, and assign automated functions to drive events.

The following major sections are covered:

- [“Connecting to the Drive” on page 17](#)
- [“Configuring the Drive” on page 21](#)
- [“Tuning and Commutation” on page 71](#)

Follow the procedures in this chapter to get an overview of many functions. Familiarize yourself with the files on your computer, the software workspace and controls of the software. Later chapters provide more details in using these functions.

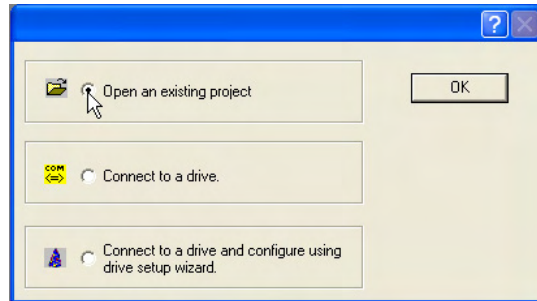
Before proceeding, you must accomplish the following actions:

- ☐ Read the release notes and installation text files for your setup software version.
- ☐ Install the setup software.

Getting Started

After installing the setup software on your computer, you can run the application from your Start > Programs menu.

When you first start the setup software, you see the following choices:



- **Open an existing project** - This will allow you to browse through the files on your computer to select a previously saved project to open, without having to connect to a drive. The project can then be configured or modified before downloading the project file into a drive.
- **Connect to a drive** - This will allow you to immediately connect to a drive. The drive can then be set up and configured for operation, and the information saved as a project file.
- **Connect to a drive and configure using drive setup wizard** - This will allow you to immediately connect to a drive, then the setup software will take you through the necessary steps to configure the drive for operation. The information can then be saved as a project file.

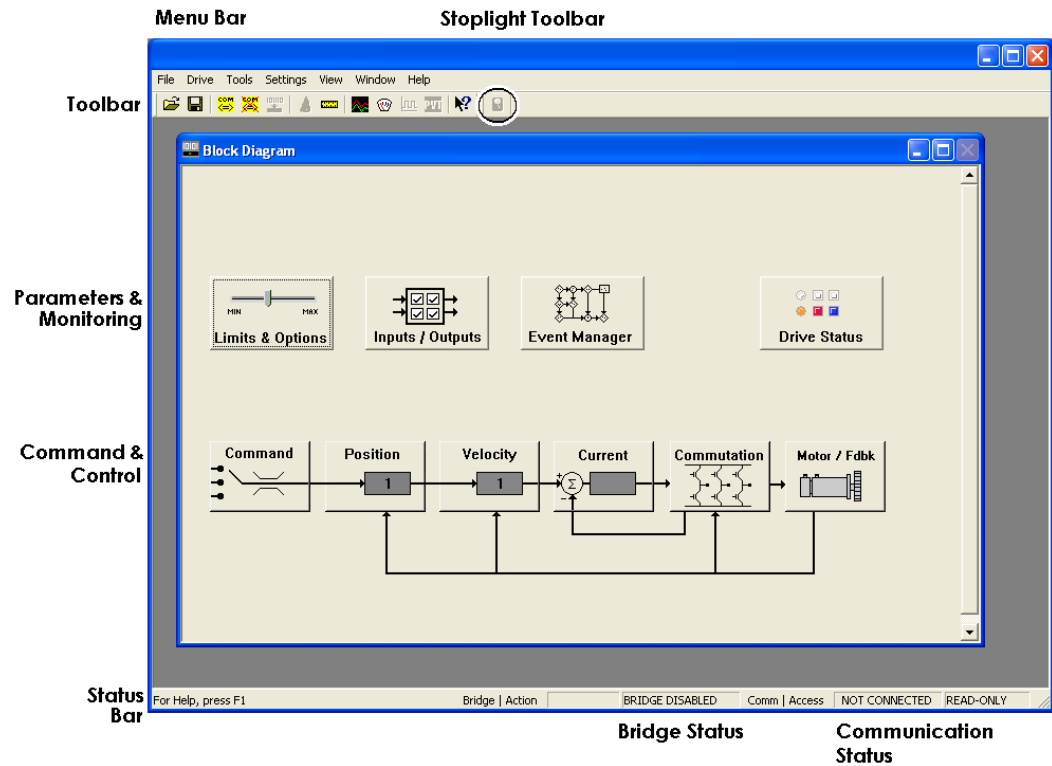
Software Files

Look in the folder in which you placed the application; by default, this location is under C:\Program Files. This folder includes the subdirectories:

- **MotorDB** holding a library of *.dbs *database files* making up the motor database.
- **My Firmware Files** holding a library of *.aff *firmware files* for various drives.
- **My Projects** holding a library of *.adf *project files*, each with the parameters and controls specific to a particular drive-and-motor setup.

Workspace Display

The software provides functions, tools and status to help you set up your drive.



Menu and Toolbar At the top of the screen are pull down menus and a toolbar. You can access many tools and functions to accomplish tasks such as managing files or configuring tools.

Function	Menu Pull-down	Toolbar	Keys
Open a file	File >	Open	Crtl+O
Save a file		Save	Crtl+S
Save as a file name		---	---
Start the configuration Wizard		Wizard	---
Close the program		Exit	Alt+F4

Function	Menu Pull-down		Toolbar	Keys
Power up or down the bridge	Drive >	Enable/Disable		---
Connect to the drive		Connect (or)		---
Change settings once connected		Connection Settings		---
Disconnect from the drive		Disconnect		---
Store project on the drive		Store to drive		---
Upload settings from drive		Restore from drive	---	---
Update drive firmware		Firmware Download	---	---
Monitor drive signals on a digital scope	Tools >	Oscilloscope		---
Monitor drive signals numerically		Multimeter		---
Generate command waveforms to the drive		Waveform Generator		---
Work with PVT files and PVT points		PVT Generator		---
Set measuring parameters	Settings >	User Units		---
Assign actions to Bridge Disable and set Commanded Inhibit keys		Stoplight Settings	---	F4

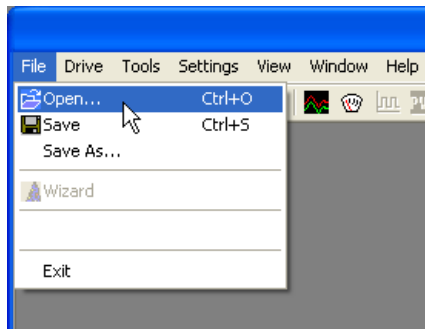
Assign a name to a drive		Drive Name	---	---
Change Drive Library Settings	DriveLibrary			
Monitor activity and faults	View >	Drive Status	---	---
Access stored logs and counters of critical event activity and faults		Event Logs		
Display or hide icons		Toolbar	---	---

Function	Menu Pull-down	Toolbar	Keys
Overlap software windows	Window >	Cascade	---
Adjoin software windows		Tile	---
See on-line documentation	Help >	Help...	F1
Get contextual help for workspace		What's This? 	Shift+F1
Display version of software		About...	---
Display drive hardware and firmware information		About The Drive	---

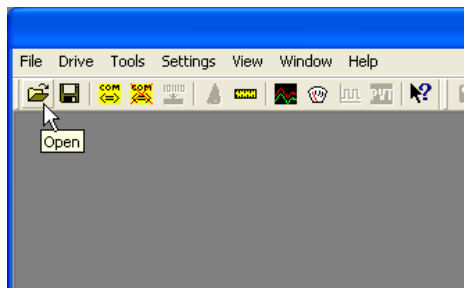
The workspace display often allows more than one path to a particular function.

For example, to open a project file, choose one of these actions:

- Select File > Open on the main menu bar.

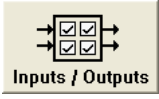
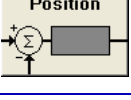
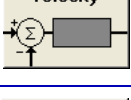
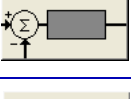
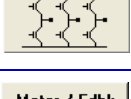


- Click the Open icon  on the tool bar.



Block Diagram The main window is a block diagram representing the digital servo drive. Use this window to navigate to other areas for setup, configuration, diagnostics and troubleshooting. At the top are the blocks used for general configuration and checking drive status. At the center are the internal loops:

current, velocity, and position. These loops are nested and you should tune starting with the most inner loop.

Function	Block Diagram	Menu
Configure general drive parameters	 Limits & Options	---
Configure and diagnose analog and digital signals	 Inputs / Outputs	---
Configure drive fault and event handling	 Event Manager	---
See a status overview of internal, system and drive faults	 Drive Status	View > Drive Status
Select types of motor control signals	 Command	---
Adjust settings, gains and limits for the Position Loop	 Position	---
Adjust settings, gains and limits for the Velocity Loop	 Velocity	---
Adjust settings, gains and limits for the Current Loop	 Current	---
Configure commutation settings	 Commutation	---
Enter motor data and select feedback for velocity and position signals	 Motor / Fdbk	---

Using the Setup Software

The setup software provides many tools to configure and monitor the settings for the drive. Later chapters go into detail about these tools, but briefly, this section describes how to:

- Open a file
- Name the drive
- Connect to and disconnect from the drive
- Enable and disable the power bridge
- Set the drive behavior when you disable the power bridge
- Use a Hotkey to disable the power bridge
- Show and hide the toolbars
- Move, scroll and arrange the windows

Opening a File

The setup software must be *disconnected* from the drive before performing this task.

1. To open an existing project file from your computer, perform one of the following actions
 - Select File > Open on the main menu bar.
 - Click on the Open icon  on the tool bar.
2. Browse your computer to the My Projects subdirectory or wherever your project files are saved, and select a project (.adf extension).

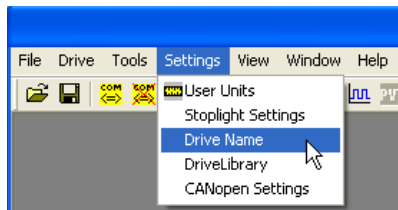
Once opened, you can connect to the drive and choose to either download the project file configuration settings into the drive, or upload the configuration settings from the drive into the setup software. For more information, see [“Connecting to the Drive” on page 17](#).

Working with the Drive

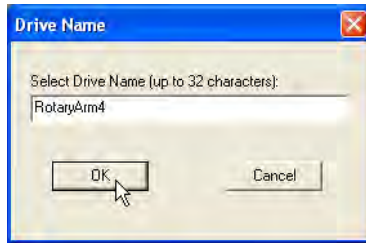
There are several tasks you must accomplish to configure and set up the drive. Later chapters go into detail about these tasks.

Naming the drive The Drive Name data field allows you to assign a unique name to the drive (such as "X-Axis"). You may enter a name up to 32 characters.

1. Select Settings > Drive Name, on the menu bar.



2. In the data field, type the name of the drive.
3. Click on the OK button.



Connecting to the drive You must start communicating with the drive before performing any configuration and setup. Choose one of these actions:

- Select Drive > Connect on the main menu bar.
- Click on the Connect icon  on the tool bar.

When you connect, you decide whether to upload the configuration settings currently in the drive or download the current project from the setup software into the drive.

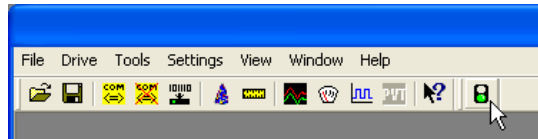
While connected to the drive, the status bar in the lower, right-hand corner of the workspace reads CONNECTED and you can perform most configuration tasks.

Disconnecting from the drive When it is time to stop communicating with the drive, you must disconnect from the drive. Choose one of these actions:

- Select Drive > Disconnect on the main menu bar.
- Click on the Disconnect icon  on the tool bar. After terminating communication with the drive, the status bar in the lower, right-hand side of the workspace reads NOT CONNECTED.

Working with the Stoplight

The Stoplight icon indicates whether the power bridge circuit is ready and the drive is ready to process motion commands, or if motion is disabled and the drive will not provide high voltage to the motor phase terminals.



In later chapters, when you actually enable the bridge, the motor will have power and can move. You must take care so as to avoid damage to equipment or injuries to people.

Enabling motion This action allows the drive to accept commands and to send power to the motor. Choose one of these actions:

- Select Drive > Enable on the main menu bar.
- Click on the Stoplight icon on the tool bar so that it is green  .

With the bridge enabled, you can perform the phase detection, AutoCommutation, and tuning tasks required before motion can be controlled. Later chapters explain these procedures.



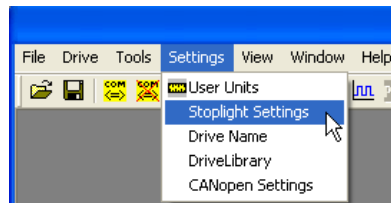
Keep in mind that when the Stoplight is green, the drive is software enabled, but a hardware event (digital input, invalid hall state, etc) could still keep the power bridge from enabling.

Disabling motion This action stops the drive from providing high voltage to the motor phase terminals. Many functions *automatically* disable the bridge. At other times, you may need to *manually* disable the bridge or stop motion. Choose one of these actions:

- Select Drive > Disable on the main menu bar.
- Click on the Stoplight icon on the tool bar so that it is red  .

Stoplight behavior and Hotkey This window allows you to select the behavior associated when the Stoplight icon is selected from within the software. It does not apply to user inhibits or event-related inhibits. When you enable and disable motion using the Stoplight icon, you can set the behavior of the Stoplight:  .

Select Settings > Stoplight Settings on the main menu bar.



This window allows you change the disabling behavior of the Stoplight and set which keyboard keys to use as a shortcut:



Commanded Disable	The Stoplight will behave like a Commanded Disable. The action associated with a commanded disable may be specified in Event Manager.
Commanded Quick Stop	The Stoplight icon will behave like a Quick Stop Command.

Quick stop behaves differently depending which mode the drive is in. For current mode, Quick Stop will disable the power bridge. For velocity mode, quick stop will command a zero velocity. For Position mode, quick stop will decelerate and hold position.

When you press the Hotkey, it is the same action as disabling motion through the pull-down menu or clickable icon. You can use the Hotkey at any time. To reassign keystrokes for the Commanded Inhibit:

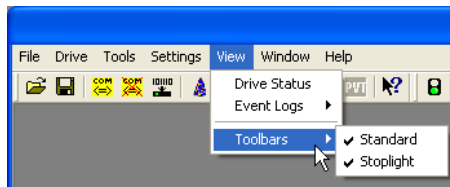
1. Select Settings > Stoplight Settings on the main menu bar.
This action displays a window allowing you to reassign the key combinations.
2. Make sure the cursor is placed in the edit box.
3. Press any of the function keys (F2-F12).
4. Click the OK button.

Working with Windows

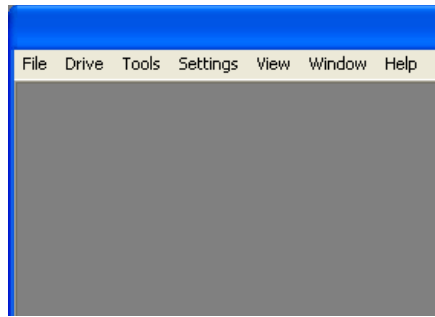
The setup software often requires several windows open at once.

Showing/hiding the toolbars To allow more room in the workspace, you can hide both the Standard toolbar and the Stoplight toolbar.

1. Select View > Toolbars on the main menu bar.



2. Select or deselect either Standard or Stoplight depending on your preference.



Standard provides the option of hiding or displaying the toolbar.

Stoplight provides the option of hiding or displaying the Stoplight  that enables and disables the drive's power bridge.

Moving a window Click-and-hold the mouse pointer over the title bar of the window and drag it to another position.

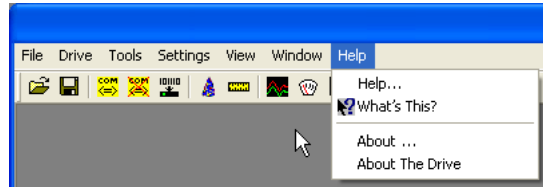
Scroll bars Displayed at the right and bottom edges of the document window, the scroll boxes inside the scroll bars indicate your vertical and horizontal location in the document. Click-and-hold the mouse pointer to scroll to other parts of the document.

Arranging the windows

- To overlap all non-minimized windows, select Windows > Cascade on the main menu bar.
- To adjoin all non-minimized windows, select Windows > Tile on the main menu bar.

Getting Help

The Help menu offers assistance with this application.



On-Line Documentation

To open the on-line documentation, either:

- Select Help > Help... on the main menu bar.
- Press the F1 key.

Context Help

In the workspace display, you can use the Context Help to go to on-line explanations of some part of the setup software.

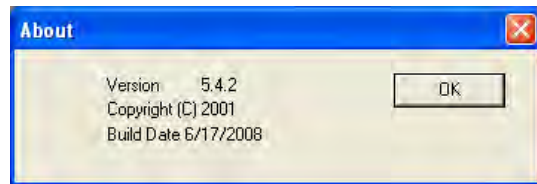
To use Context Help, either:

- Select Help > What's This? on the main menu bar.
- Click the Context Help icon  on the tool bar.
 - When you choose the tool bar's Context Help button, the mouse pointer changes to an arrow and question mark.
 - Click somewhere in the window. The Help topic will be shown for the item you clicked.

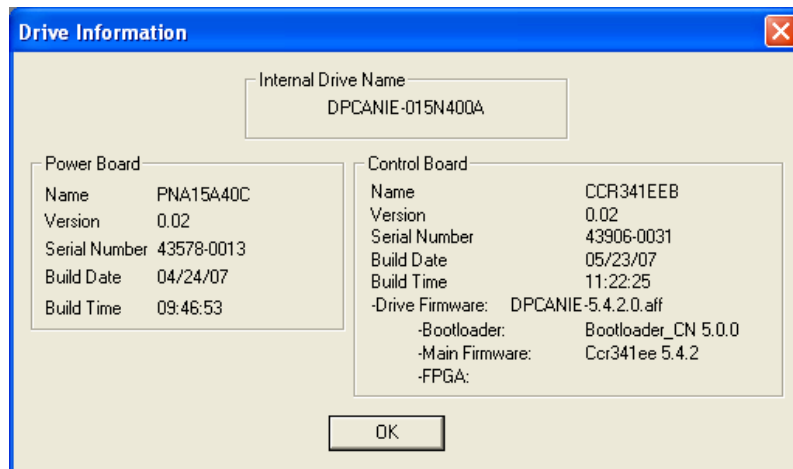
Technical Support

If you need to contact technical support with a problem or question, please have this information readily available.

Software version To display the version number of your copy of the setup software, select Help > About... on the main menu bar.



Display the drive information To display information about the drive's internal hardware and software, select Help > About The Drive on the main menu bar.



Saving Your Setup

After you have configured your drive, you must make certain to save all the parameters and settings.

Storing the Changes onto the Drive

The setup software must be *connected* to the drive before performing this task.

After you configure and adjust the drive's settings, use the store function. The drive settings stored in the drive's nonvolatile memory (NVM) are used by the drive after an off-on power cycle.

To save the current drive settings in nonvolatile memory, you would either:

- Select Drive > Store to drive on the main menu bar.
- Click on the Store icon  on the tool bar.

Click OK in the dialog box to confirm you action.

Saving the Project File onto Your Computer

Use this command to save the active configuration project file to its current name and directory. When you save a file for the first time, the software displays the Save As dialog box so you can name your document.

To overwrite your project file on the computer with your current changes in the setup software, you would either:

- Select File > Save on the main menu bar.
- Click on the Save icon  on the tool bar.

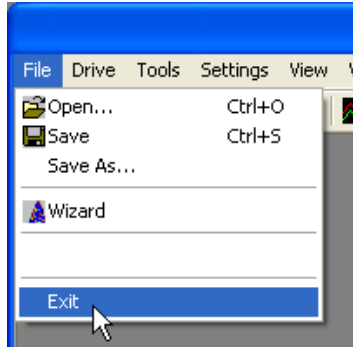
If you want to change the name and directory of an existing document before you save it, choose the Save As command. Use this command to save and name the active document. The setup software displays the Save As dialog box so you can name your document.

1. Select File > Save as on the main menu bar.
2. Enter a file name in the dialog box.

Exiting the Program

Use this command to end your configuration session. To exit the program, either:

- Select File > Exit on the main menu bar.

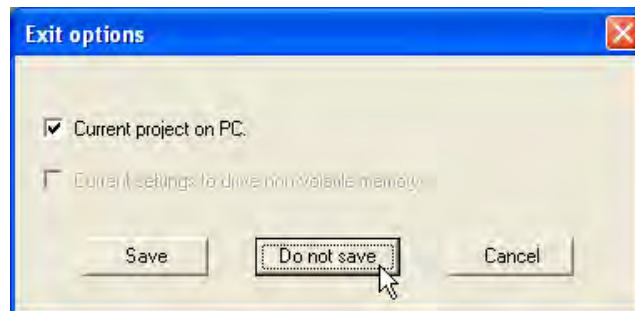


or:

- Double-click on the upper left corner of the main window.



The software prompts you to save documents with unsaved changes.



- **Current project on PC** - Saves the current project file to the PC before exiting.
- **Current settings to drive non-volatile memory** - Saves the current project settings to the drive non-volatile memory before exiting.

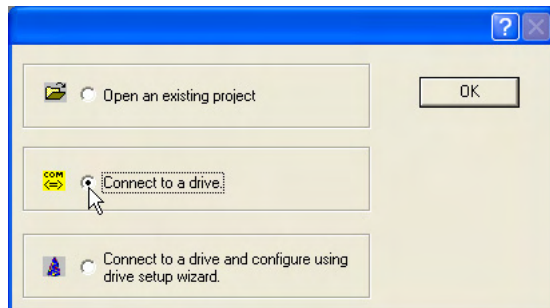
2 Connecting to the Drive

Before proceeding, you must accomplish the following actions:

- ☐ Read the data sheet for the drive and the specification sheet for the motor and be familiar with their capabilities.
- ☐ Cable your computer's serial port to the drive.
- ☐ Wire the drive to the motor.
- ☐ Provide electrical power to the drive; the drive, in turn, provides power to the motor.

Connecting to the Drive

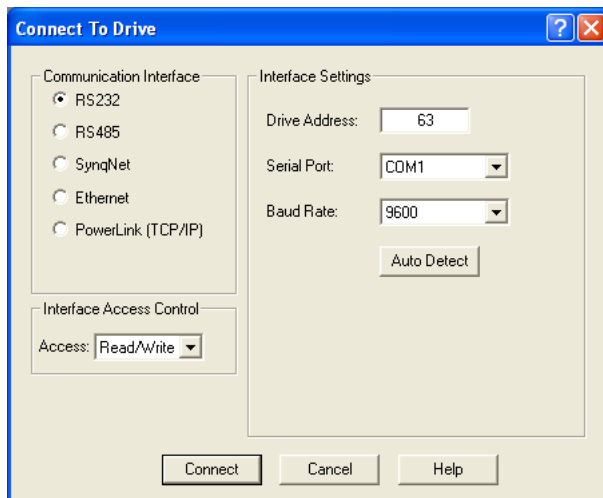
When you first start the setup software, you see the following choices:



For now:

1. Select Connect to a drive.
2. Click the OK button.

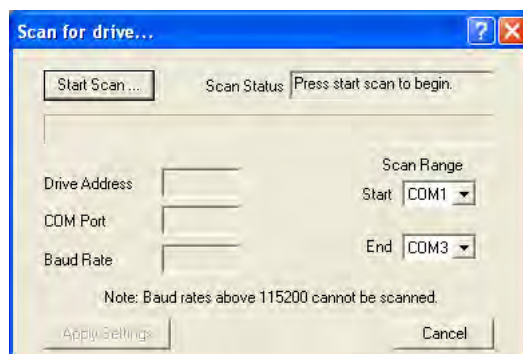
The following window appears when Connect to drive is selected from the opening page.



You must initially connect to the drive using the factory default settings stored in nonvolatile memory and the appropriate serial port selected from the PC.

Option	Default Setting	Description
Communication Interface	RS232	Selects the appropriate interface for your application.
Drive Address	63	Selects the address of the drive that is connected to the PC. The valid range of addresses is 1 - 63.
Serial Port	COM1	Selects the serial communication port to which the drive is connected.
Baud Rate	9600	Selects the communication baud rate.
Interface Access Control		Under normal circumstances, Read/Write should be selected. You may select Read Only to put the software in a state that allows monitoring through the configuration software while writing through another interface.
Auto Detect		This button allows you to automatically detect the serial port and baud rate stored in your drive. You can set a range for the COM port scan. When this button is selected, the Scan for drive... window will pop up. Select Start Scan ... and wait for the program to go through the detection routine. After successful detection, select Apply Settings.
Connect		Establishes a connection with the specified settings. If you have a project open, you can choose to download the current project settings to the drive, or to upload the stored drive settings into the project. The status bar in the lower right corner of the setup software will change from NOT CONNECTED to CONNECTED.
Cancel		Closes the connection window without connecting.
Help		Brings up this help document.

If the drive has previously been configured, these settings may have changed. If connecting fails, click on the Auto Detect button.



Autodetect Window

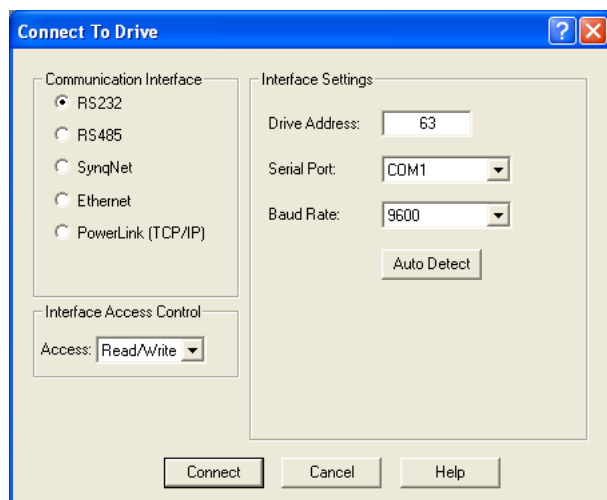
Saving the Drive's Default Configuration

When you connect, the setup software reads the configuration settings from the drive and that data becomes the current project. Now would be a good time to save these settings to your computer using a unique name to identify these factory-set drive parameters. If you need to review, see [“Saving the Project File onto Your Computer” on page 14.](#)

Changing Communication Parameters

Once communication is established, you may change the address and baud rate settings.

1. Choose one of the following actions:
 - Select Drive > Connection Settings on the main menu bar.
 - Click on the Connect icon  on the tool bar.
2. Choose your desired settings.
3. Click the OK button.



Connection Settings Window

The new settings take effect immediately. In order to retain the new settings upon power-up, they must be stored in the drive's nonvolatile memory. If you need to review, see [“Storing the Changes onto the Drive” on page 14.](#)

3 Configuring the Drive

Before proceeding, you must accomplish the following actions:

- ☐ Successfully connect your computer to the drive.
- ☐ Use the setup software to successfully recognize the drive.
- ☐ Wire the drive to the motor.

Configuration requires you to decide upon several parameters for your drive based on the requirements of your application. The drive must have information about scale factors, feedback devices, motor parameters, and limits.

The setup software provides windows for you to:

- Assign the user units of measurements.
- Enter the motor constants.
- Set the primary feedback.
- Select the feedback data (velocity and/or position).
- Set the limits for temperature, current, voltage, velocity and position and decide options for power-up and brake/stop behavior.
- Enter the command source.
- Decide which analog and digital signals will provide input and output for the drive.

All these parameters are collected in a *project file*. You can save several project files on your computer (they have the *.adf extension). From your computer, a file can be downloaded to—or uploaded from—the drive. Once in the drive, you must store the file in the drive's read-only memory.

This chapter discusses each window and the various data they accept. Once you have completed configuration, the drive will be ready for tuning and commutation.



The Restore function loads into your computer's project file the parameters stored in the drive's non-volatile memory. Use Restore when wish to revert back to the parameters last stored in the drive if you find your recent changes result in poor performance.

Select Drive > Restore from drive on the main menu bar.

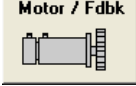
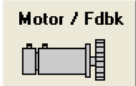
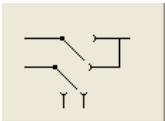
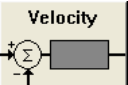
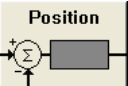
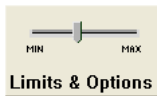
Using the Configuration Wizard

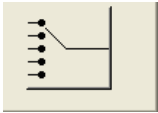
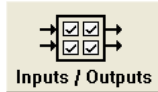
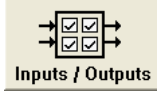
The easiest way to configure a new drive is to use the **Drive Configuration Wizard**. The wizard takes you to each of the necessary windows to configure the drive parameters.

To use the wizard, do one of the following:

- Select File > Wizard on the main menu bar.
- Click the drive configuration wizard icon  on the tool bar.

Click through the tabs and fill in the appropriate data once the wizard navigates to a window. The wizard will take you through the following windows:

Wizard Window	Navigation when not using Wizard	Icon
Motor and Feedback Data 	Main Block diagram > Motor / Fdbk block	
User Units 	Settings > User Units	
Motor Feedback Data 	Main Block Diagram > Motor /Fdbk block > Primary Feedback tab	
Feedback Selection 	Main Block Diagram > Velocity loop > Velocity Feedback tab	
	Main Block Diagram > Position loop > Position Feedback tab	
Limits & Options 	Main Block diagram > Limits & Options	

Wizard Window	Navigation when not using Wizard	Icon
Command Source 	Main Block diagram > Command	
Inputs / Outputs 	Main Block diagram > Inputs / Outputs	

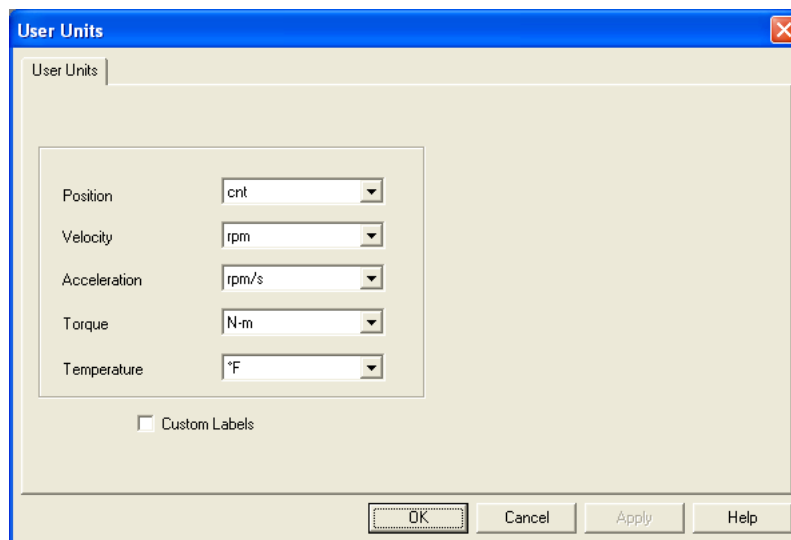
User Units

This window allows you to select measurements for your motor and load. For example, you could track your motor speed in RPM while you track your load speed in m/s. You can select from a variety of units types and even define custom units.

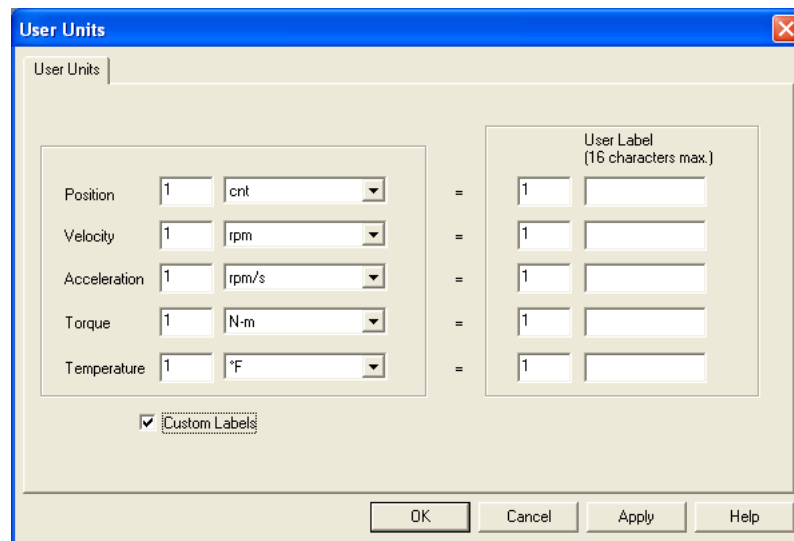
To open the User Units window, do one of the following:

- Select Options > User Units on the main menu bar.
- Click the User Units icon  on the tool bar.

User Units Tab



The User Units tab allows you to set the general units you will use in the software. Select the type of unit from the drop down menu.

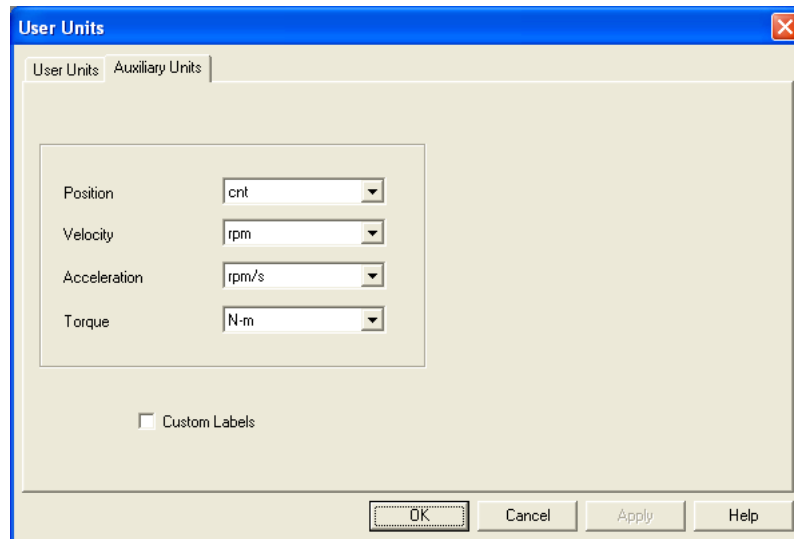


The 'User Units' dialog box is shown with a blue title bar and a close button. It contains a 'User Units' tab and a 'Custom Labels' checkbox which is checked. The main area is divided into two columns. The left column lists five physical quantities: Position, Velocity, Acceleration, Torque, and Temperature. Each quantity has a numeric input field (all set to '1') and a unit dropdown menu (set to 'cnt', 'rpm', 'rpm/s', 'N-m', and '°F' respectively). The right column is titled 'User Label (16 characters max.)' and contains five corresponding empty text input fields. Each row is separated by an equals sign '='. At the bottom are four buttons: 'OK', 'Cancel', 'Apply', and 'Help'.

Quantity	Value	Unit	User Label
Position	1	cnt	
Velocity	1	rpm	
Acceleration	1	rpm/s	
Torque	1	N-m	
Temperature	1	°F	

You may also define custom units by checking the Custom Labels box. Once selected, you may choose any name you like to define your custom units. You can also adjust scaling differences between standard and custom units.

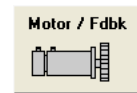
Auxiliary Units Tab



The auxiliary tab is available only when the Auxiliary Encoder checkbox is checked from within the Motor/Fdbk block. This tab allows you to set auxiliary units when using dual-loop feedback. You may define custom auxiliary units by checking the Custom Labels checkbox.

Motor and Feedback Data

The motor and feedback data windows can be accessed by clicking on the Motor/Fdbk icon in the main block diagram.



The motor data are stored in:

- The drive.
- The project file.
- The motor database.

Manufacturer	The name of the motor manufacturer
Model	The motor model
Motor Type	The type of motor used. The brushed and brushless motor types pertain to rotary motors. The linear brushless motor type pertains to linear motors.
Feedback Model	The type of feedback to be used with the motor.

Motor And Feedback Data

Manufacturer: Default Motor
 Model: Default Brushless
 Motor Type: Brushless
 Feedback Model: 120° Halls, 2000 Line Encoder

View Database
 Save to Database

Motor Constants | Primary Feedback | Auxiliary Feedback | Wire Identification

Voltage Constant: 8.2 V/Krpm
 Torque Constant: 11.09 oz-in/A
 Resistance: 3.69 Ohm
 Inductance: 5.94 mHenry
 Max Motor Temperature: 212 °F

Maximum Current: 5.9 Amps
 Rated Current: 2 Amps
 Number of Poles: 4
 Maximum Speed: 4000 rev/min

OK Cancel Help

Motor Constants Tab

The screenshot shows the 'Motor And Feedback Data' dialog box with the 'Motor Constants' tab selected. The dialog has a blue title bar and a close button (X) in the top right corner. Below the title bar, there are input fields for 'Manufacturer' (Default Motor), 'Model' (Default Brushless), 'Motor Type' (Brushless), and 'Feedback Model' (120° Halls, 2000 Line Encoder). To the right of these fields are two buttons: 'View Database' and 'Save to Database'. Below these fields is a tabbed interface with four tabs: 'Motor Constants' (selected), 'Primary Feedback', 'Auxiliary Feedback', and 'Wire Identification'. The 'Motor Constants' tab contains several input fields arranged in two columns. The left column includes 'Voltage Constant' (8.2 V/Krpm), 'Torque Constant' (11.09 oz-in/A), 'Resistance' (3.69 Ohm), 'Inductance' (5.94 mHenry), and 'Max Motor Temperature' (212 °F). The right column includes 'Maximum Current' (5.9 Amps), 'Rated Current' (2 Amps), 'Number of Poles' (4), and 'Maximum Speed' (4000 rev/min). At the bottom of the dialog are three buttons: 'OK', 'Cancel', and 'Help'.

The Motor Constants tab is where you will input the motor ratings and motor-specific data.



Note

The values entered in the Motor Constants tab will have an effect on the values entered in the Limits and Options block discussed later in this chapter. For reference, see [“Limits & Options” on page 37](#)

Enter the following information:

Voltage Constant	The voltage constant corresponds to the motor back-EMF constant. This value can be obtained from the motor data sheet. The numerical value and units can be selected independently (the numerical value will NOT be automatically re-calculated when a different unit is selected).
Torque/Force Constant	This value can be obtained from the motor data sheet. The numerical value and units can be selected independently (the numerical value will NOT be automatically re-calculated when a different unit is selected).
Resistance	This value can be obtained from the motor data sheet. In case of brushed type motors it corresponds to the armature resistance. In case of brushless motors it corresponds to the phase-to-phase resistance.
Inductance	This value can be obtained from the motor data sheet. In case of brushed type motors it corresponds to the armature inductance. In case of brushless motors it corresponds to the phase-to-phase inductance.
Max Motor Temperature	Maximum allowable motor temperature. This information can be obtained from the motor data sheet.
Maximum Current	The maximum current is the peak operating current that the motor can handle. This does not correspond to the de-magnetizing current, which is typically much higher than the maximum operating current. This value can be obtained from the motor data sheet. (Note: The specified current is in units of peak current. This is the peak value allowed to go through any phase of the motor within one electrical cycle. To calculate the RMS current, divide the peak value by 1.414. This calculation should not be used when the motor is commutated trapezoidally.)
Rated Current	The rated current is the nominal (continuous) current that the motor can handle. This value can be obtained from the motor data sheet. (Note: The specified current is in units of peak current. This is the peak value allowed to go through any phase of the motor within one electrical cycle. To calculate the RMS current, divide the peak value by 1.414. This calculation should not be used when the motor is commutated trapezoidally.)
Number of Poles/Pole Pitch	The number of poles, in case of rotary motors, corresponds to twice the number of electrical cycles per motor revolution. The pole pitch, in case of linear motors, corresponds to the length of one electrical cycle (360 degrees). The numerical value and units can be selected independently (the numerical value will NOT be automatically re-calculated when a different unit is selected). This information can be obtained from the motor data sheet.
Maximum Speed	The maximum speed corresponds to the maximum speed of the motor. The numerical value and units are dependent. This information can be obtained from the motor data sheet.

Primary Feedback Tab

The screenshot shows the 'Motor And Feedback Data' dialog box with the 'Primary Feedback' tab selected. The 'Motor Constants' tab is also visible. The 'Motor Type' is set to 'Brushless' and the 'Feedback Model' is '120° Halls, 2000 Line Encoder'. The 'Hall Sensors' section has '120° Hall Phasing' selected. The 'Motor Encoder' section has '2000 Lines/Rev' and 'Standard' feedback polarity. The 'Index' section has '1 Indices / Rev'. The 'Rotation Direction' is set to 'Standard'. A note states: 'Note: AutoCommutation will detect the proper feedback settings if unknown.' Buttons for 'View Database', 'Save to Database', 'OK', 'Cancel', and 'Help' are present.

Enter the following model-dependent data:

Hall Sensors	Check the box if hall sensors are available and connected. Also select the hall phasing type. Note: The hall phasing will be automatically selected after running AutoCommutation™ Detection. If the hall sensor phasing differs from 60° or 120° by more than 10 electrical degrees, Other Hall Phasing will be automatically selected.
Motor Encoder	Check the box if a motor mounted encoder is connected. AutoCommutation™ Detection will determine the polarity. Enter the encoder line count per revolution (per mm/inch for linear motor). Also indicate if there is an encoder index pulse, and the number of index occurrences per revolution (number of lines per index occurrence for linear motor).

In case of resolver feedback, you can select either high or low resolution (12-bit means an equivalent 4096 counts/rev, 14-bit means 16384 counts/rev).

In case of 1Vp-p encoder feedback, you can select the number of encoder cycles per revolution and an interpolation value.

In case of a *Hiperface* or *EnDat* absolute encoder, you can select the number of encoder cycles per revolution, the serial interface, and the absolute encoder resolution.

Auxiliary Feedback Tab

Motor And Feedback Data

ManufacturerDefault Motor

ModelDefault Brushless

Motor TypeBrushless

Feedback Model120° Halls, 2000 Line Encoder

View Database

Save to Database

Motor Constants

Primary Feedback

Auxiliary Feedback

Wire Identification

☒Auxiliary Encoder

Rotary

Encoder Type

500Lines / Rev

InvertedFeedback Polarity

☒Index

1Indices / Rev

OK

Cancel

Help

Under the Auxiliary Feedback tab, the following data can be entered:

Auxiliary Encoder	Check the box if an auxiliary encoder will be used to close the position loop. It is important to leave this box unchecked if an auxiliary encoder will not be used. Select from Rotary or Linear encoder types. Select the feedback polarity that will result in a positive measured change in position from a positive command.
Index	Check this box if an auxiliary index exists. Specify the number of indices per encoder revolution, or the number of lines per index if using a linear encoder.

Wire Identification Tab

The screenshot shows the 'Motor And Feedback Data' dialog box with the 'Wire Identification' tab selected. The dialog has a blue title bar and a close button (X) in the top right corner. Below the title bar, there are input fields for 'Manufacturer' (Default Motor), 'Model' (Default Brushless), 'Motor Type' (Brushless), and 'Feedback Model' (120° Halls, 2000 Line Encoder). To the right of these fields are two buttons: 'View Database' and 'Save to Database'. Below the input fields is a tabbed interface with four tabs: 'Motor Constants', 'Primary Feedback', 'Auxiliary Feedback', and 'Wire Identification' (which is currently selected). The 'Wire Identification' tab contains four main sections: 'Motor Phase', 'Hall Sensors', 'Primary Encoder', and 'Auxiliary Encoder'. The 'Motor Phase' section has three sub-sections: 'Phase A' (four red squares), 'Phase B' (four white squares), and 'Phase C' (four blue squares). The 'Hall Sensors' section has three sub-sections: 'Hall 1' (four orange squares), 'Hall 2' (four yellow squares), and 'Hall 3' (four purple squares). The 'Primary Encoder' section has three sub-sections: 'Encoder A' (four 1s), 'Encoder B' (four 3s), and 'Encoder Index' (four 5s). The 'Auxiliary Encoder' section has three sub-sections: 'Aux Encoder A' (four empty boxes), 'Aux Encoder B' (four empty boxes), and 'Aux Encoder Index' (four empty boxes). At the bottom of the dialog are three buttons: 'OK', 'Cancel', and 'Help'.

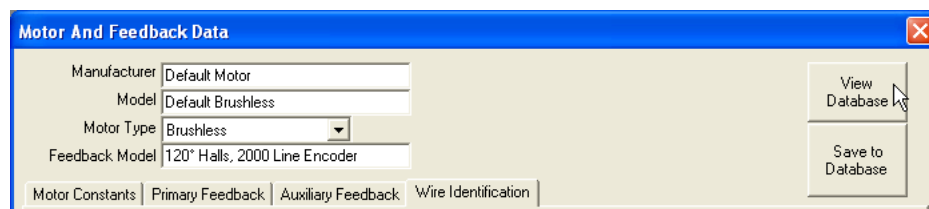
The wire identification tab is available to document color-coded and number-coded motor and feedback wires.

Motor Database

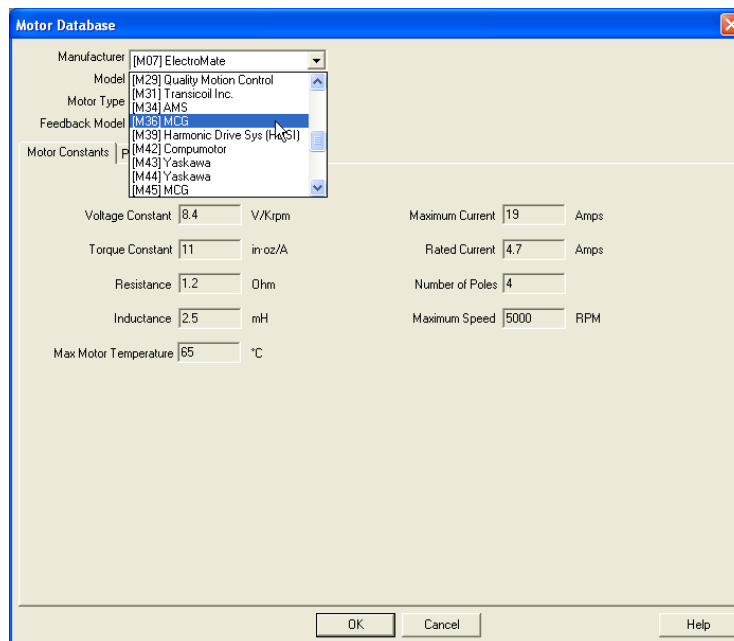
The motor database stores motor and feedback data. This avoids repetitive entry of the same data when you regularly use a certain set of motors. You can find the motor and feedback data files on your computer (they have the *.dbs extension) in the MotorDB subdirectory as ASCII text files.

Saving motor data To save the existing motor specifications to the database, click on the Save to Database button. The motor data including feedback and wire identifications will be saved.

Retrieving motor data To find your motor in the data base:



1. Click on the View Database button. The Motor Database window appears.
2. Select a motor manufacturer from the drop-down list.
3. Select a model from the drop-down list.

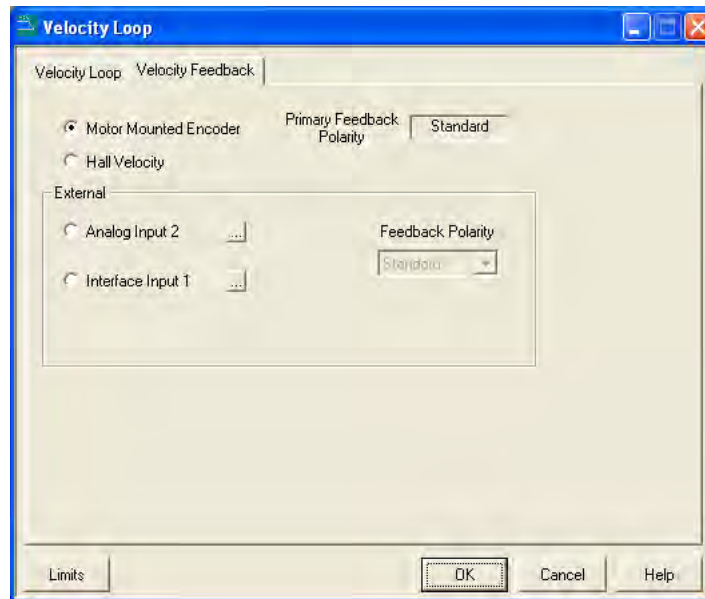


4. Click the OK button.

Feedback Assignment

Open the Feedback window by clicking on the velocity or position loop block in the main block diagram, and then clicking on the feedback tab. It allows selection of the feedback used by the velocity and position loops.

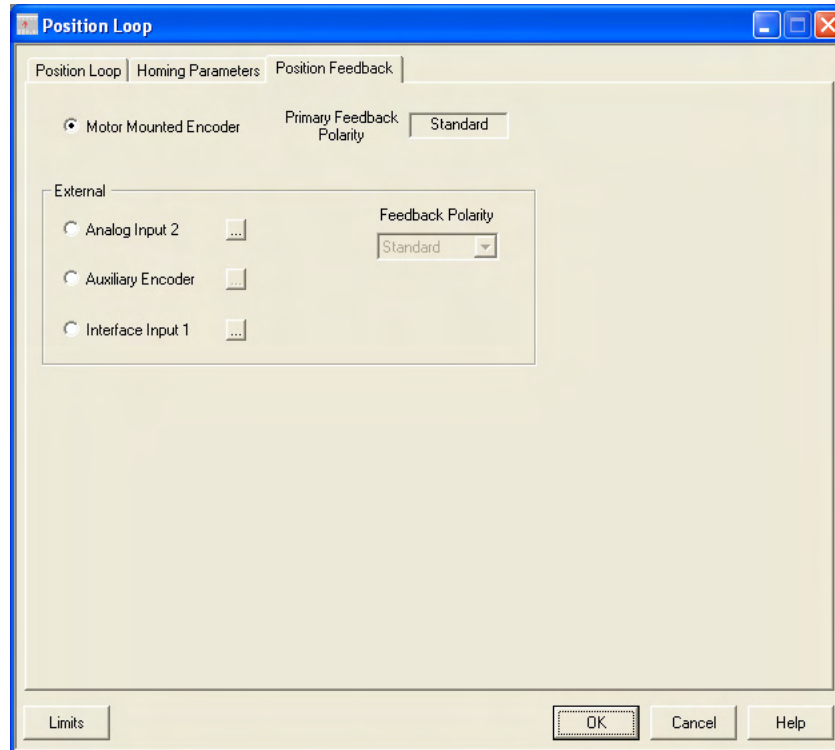
Velocity Feedback Tab



Motor Mounted Encoder	The velocity is derived from the motor mounted encoder.
Hall Velocity	The velocity is derived from the motor mounted hall sensors. When configured for hall velocity mode, the drive will define 1 count to be equal to 1 hall state change (that is, a 4-pole motor has 12 counts per revolution).
Analog Input	The velocity is derived from an analog input. Typically used in case of a motor mounted tachometer. The analog signal must be conditioned not to go outside the range of +/-10V. For drives with multiple analog inputs, click on the  to select which analog input to use.
Interface Input	The velocity is provided over the communication interface. This is an advanced option which is currently not available with standard drives.
Resolver	The position is derived from the motor mounted resolver.
Feedback Polarity	Represents the polarity of the selected feedback device signal.

For reference, see [“Filtering Velocity Feedback” on page 149](#).

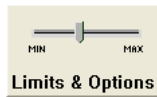
Position Feedback Tab



Motor Mounted Encoder	The position is derived from the motor mounted encoder.
	Interpolation: Sinusoidal encoder drives will have the option for adjusting the interpolation. This number specifies the number of "counts" per encoder cycle that the drive processes.
Analog Input	The position is derived from an analog input. Typically used in case of a load-mounted potentiometer. The analog signal must be conditioned not to go outside the range of +/-10V. For drives with multiple analog inputs, click on the ellipses ... to select which analog input to use/
Auxiliary Encoder	The position is derived from the auxiliary encoder input.
Interface Input	The position is provided over the interface.
Resolver	The position is derived from the motor mounted resolver
Feedback Polarity	Represents the polarity of the selected feedback device signal.

The availability of the above selections depends on the model of the drive.

Limits & Options



The Limits & Options window allows configuration of general drive parameters. These limits have associated events (see Drive Status and Event Manager).

The following tabs are available:

- Drive Current Limits
- Voltage Limits
- Position Limits
- Velocity Limits
- Temperature Limits
- Power-up Control
- Braking / Stop

Drive Current Limits Tab

The screenshot shows the 'Limits & Options' dialog box with the 'Drive Current Limits' tab selected. The settings are as follows:

- Peak Current:** 2.00 Amperes (slider from 0% to 100%)
- Continuous Current:** 1.00 Amperes (slider from 0% to 100%)
- Peak Current Time:** 2.000 Seconds (slider from 0 seconds to 65 seconds)
- Foldback Time Constant:** 10.000 Seconds (slider from 0 seconds to 65 seconds)
- Select source for current limit scaling:**
 - ☒ No Scaling
 - ☐ Analog Input 1
 - ☐ Interface Input 1

Buttons at the bottom: OK, Cancel, Apply, Help.

Use this window to set the drive output current limits within the hardware capabilities of the drive.



The specified current is in units of peak current. This is the peak value allowed to go through any phase of the motor within one electrical cycle. To calculate the RMS current, divide the peak value by 1.414. This calculation should not be used when the motor is commutated trapezoidally.)

Peak Current	Maximum output current (limited output time).
Continuous Current	The maximum continuous current level the drive will output.
Peak Current Time	The maximum time duration of peak current.
Foldback Time Constant	The time the drive will use to reduce the current to the continuous current level setting.
Current Limit Scaling	You may assign an input to change the current limit dynamically. The scaling value can be adjusted in IO Configuration.

The drive can output its rated peak current for a maximum of 2 seconds with a foldback time of 10 seconds. This defines the maximum current capability curve. Current profiles that intersect with the maximum current capability curve will be limited to stay within this envelope.

Voltage Limits Tab

The screenshot shows the 'Limits & Options' dialog box with the 'Voltage Limits' tab selected. The 'Under Voltage Limit (Volts)' is set to 230.0 and the 'Over Voltage Limit (Volts)' is set to 850.0. The 'Nominal DC Bus Voltage' is set to 720 VDC. The 'Shunt Regulator' section has 'Shunt Regulator Enabled' checked and 'Turn-on Voltage' set to 800. Under 'Internal Shunt Resistor', the values are Power (W): 100, Resistance (Ohms): 60, and Inductance (μH): 0. Under 'External Shunt Resistor', the values are Power (W): 400, Resistance (Ohms): 30, and Inductance (μH): 0. The radio buttons for shunt resistor selection are 'Use Internal Shunt Only', 'Use External Shunt Only', and 'Use Internal and External Shunt In Parallel', with the last one selected.

Use this window to set the user under and over voltage limits. These limits are restricted to fall within the hardware capability of the drive. The Nominal DC Bus Voltage should contain the normal operating DC voltage supplied to the drive. If using an AC input drive, the Nominal DC Bus voltage is equal to the AC voltage multiplied by 1.41.

If the drive has provision for connection of an external shunt resistor, the parameters of that resistor can be entered. If that provision is not available, these fields will not be available. Check the data sheet for your drive to see if an external shunt resistor can be connected.

Shunt regulator operation The shunt regulator (if available, depending on drive model) can be enabled/disabled and its turn-on voltage can be set at any given voltage below the hardware over-voltage limit of the drive. The internal shunt-resistor parameters, if present, are displayed.

The shunt regulator method is used to dissipate excess energy during periods of rapid deceleration. In most cases, this energy can be consumed in a matter of milliseconds. If a longer regeneration time is needed, the drive will limit the output to the resistor according to the following information.

- Measured Bus voltage
- Shunt resistor Power
- Shunt resistor Resistance
- Shunt resistor Inductance (if unknown, use zero)



Note

If the stated resistor power or resistance is incorrect, the drive cannot reliably regulate the power dissipated.

If using both internal and external shunt resistors it is only necessary to enter information about the external resistor. The combined power, and parallel resistance will be calculated by the drive.



Caution

There is a limit to the amount of current the drive can output to the shunt without damaging the circuitry. The resistance of the external resistor (or combined parallel resistance of internal and external resistors) should be large enough to handle this current. Follow the table below to determine the absolute minimum equivalent resistance that the shunt circuitry can handle.

Drive Voltage Range	Absolute Minimum Equivalent Shunt Resistance (Ohms)
45-132 VAC or 40-190 VDC	10
90-264 VAC or 60-400 VDC	20
187-528VAC	40

External shunt resistor power selection During a regenerative event, the shunt output will initially turn on for 10ms, and the entire bus voltage is placed across the shunt resistor to allow the excess bus voltage to fall below the shunt enable threshold during normal regeneration.



Caution

This initial turn-on is independent of the shunt resistor information entered; therefore the power dissipated through your shunt resistor may exceed the rated power during the first 10ms. If using an external shunt resistor, be sure the resistor can handle this 10ms pulse.

After this initial pulse, if the bus voltage is still higher than the shunt turn on voltage, the shunt output will turn on and off rapidly in order to regulate the power dissipated. For both external and dual shunt modes, the on time and period are adjusted such that the shunt is on for approximately 3 time constants while

maintaining the same duty cycle. The highest duty cycle attainable is 50%. The drive sets the on-time PWM output to a duty cycle such that:

$$\frac{V_{bus}^2}{R} \times DC = P_{max}$$

V_{bus}	=	measured bus voltage (Vdc)
R	=	shunt resistance (ohms) - specified in setup software for external/dual shunt
P_{max}	=	maximum shunt power (W) - specified in setup software for external/dual shunt
DC	=	PWM duty cycle

The period of the PWM output is set as $(V_{bus}^2 / (R * P_{max})) * T_{on}$, with $T_{on} = 2 / F_s$, where F_s is the switching frequency of the drive (Hz). The average current going through the shunt resistor will be less than or equal to $V_{bus} / 2R$. The average power through the shunt resistor during this time will be less than or equal to $(V_{bus})^2 / 2R$.

Velocity Limits Tab

Limits & Options	
Temperature Limits	Power-up Control
Drive Current Limits	Voltage Limits
Velocity Limits	Braking / Stop
Position Limits	
Motor Over Speed	4000 rev/min
Zero Velocity Window	10.00 rev/min
At Velocity Window	10.00 rev/min
Velocity Following Error	10.00 rev/min
Positive Velocity Limit	3500 rev/min
Negative Velocity Limit	3500 rev/min
	Motor Over Speed
	Motor Over Speed

OK Cancel Apply Help

The following velocity-related limits can be set:

Motor Over Speed	The maximum speed in which the motor should be able to go. The action following a motor overspeed event can be defined in Event Manager. (Active in all operating modes)
Zero Velocity Window	The measured velocity values, within which the motor is considered to be at zero velocity (active in all operating modes)
At Velocity Window	The "At Velocity" event will be set when the measured velocity reaches the target velocity, within the "At Velocity" window (active in velocity mode only).
Velocity Following Error	The maximum allowed velocity error (difference between target velocity and measured velocity), prior to setting the "Velocity Following Error" event (active in velocity mode only).
Positive Velocity Limit	The maximum allowed demand velocity in the positive direction (active in velocity mode only).
Negative Velocity Limit	The maximum allowed demand velocity in the negative direction (active in velocity mode only).

Position Limits Tab

Limits & Options

Temperature Limits

Power-up Control

Braking / Stop

Drive Current Limits

Voltage Limits

Velocity Limits

Position Limits

In-Home Position Window:

100

cnt

In-Position Window:

100

cnt

Position Following Error Window:

4000

cnt

Home Position Value:

0

cnt

Measured Position Value:

0

cnt

Max Measured Position Limit:

2147483647

cnt

Min Measured Position Limit:

-2147483647

cnt

Max Target Position Limit:

2147483647

cnt

Min Target Position Limit:

-2147483647

cnt

☐ Disable Position Limits

OK

Cancel

Apply

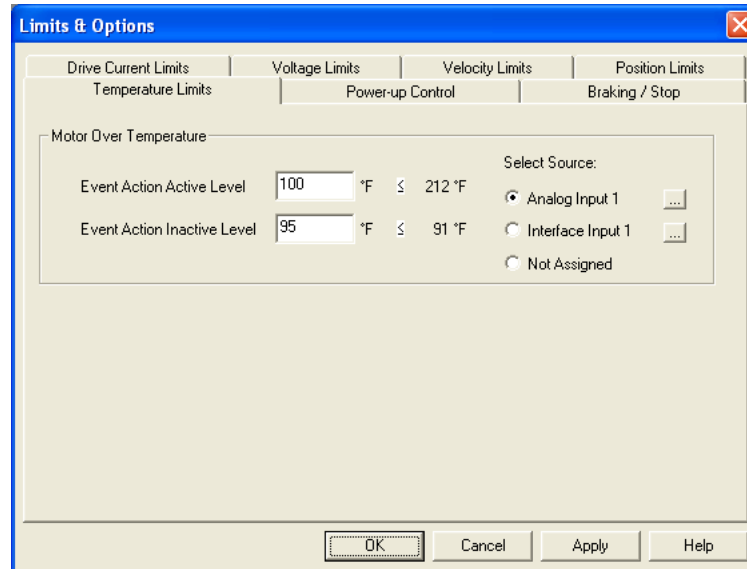
Help

Make sure the target position is set to the proper value prior to enabling the drive. Otherwise a large position following error will exist.

The following position-related limits can be set:

In-Home Position Window	Defines a window around the Home Position Value, such that when the measured position is within this window, the At-Home Position event will be active.
In-Position Window	Defines a window around the target position, such that when the measured position is within this window, the At Command event will be active.
Position Following Error Window	The maximum allowed position error (difference between target position and measured position) prior to setting the "Position FollowingError" event (active in position mode only).
Home Position Value	Position value of the home position. When the measured position reaches this position, within the In-Home Position Window, the At-Home event becomes active.
Measured Position Value	Replacement value for the measured position when the Load Measured Position event is triggered. This allows you to redefine the current measured position (e.g. reset to zero). CAUTION: make sure the target position is set to the proper value prior to enabling the drive. Otherwise a large position following error will exist.
Max Measured Position Limit	Maximum allowed measured position. The Max Measured Position event will become active if the measured position exceeds this value.
Min Measured Position Limit	Minimum allowed measured position. The Min Measured Position event will become active if the measured position exceeds this value.
Max Target Position Limit	Maximum allowed target position. The Max Target Position event will become active if the target position exceeds this value.
Min Target Position Limit	Minimum allowed target position. The Min Target Position event will become active if the target position exceeds this value.
Disable Position Limits Checkbox	Allows you to disable position limits so the motor has no maximum or minimum position value.

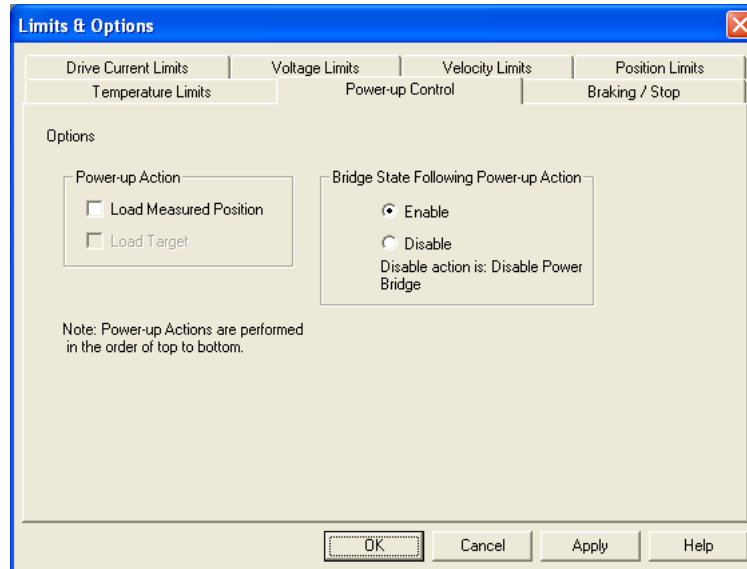
Temperature Limits Tab



If the motor has an analog temperature sensor, it can be connected to an analog input of the drive. You can configure a maximum allowable motor temperature at which point the drive will be disabled. The motor temperature level at which the drive can be re-enabled can also be configured.

For a digital temperature sensor, see the digital inputs section of [“Inputs / Outputs” on page 62](#).

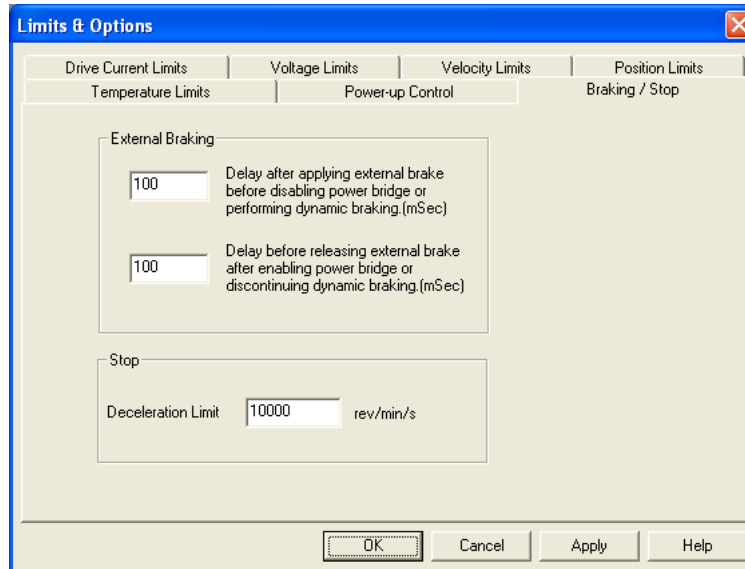
Power-up Control Tab



Power-up action

Load Measured Position	Loads the position defined in the position limits tab as home position.
Load Target	Loads the target position as defined in the Input Ratio window. This action is only active when operating in Encoder Following or Step and Direction position mode.
Bridge State Following Power-up Action	If Disable is selected, you will only be able to enable the drive using the software or sending commands through the interface. To use disable via digital inputs, see “Inputs / Outputs” on page 62 .

Braking / Stop Tab



External braking Allows you to set time delays between external braking and enabling/disabling the drive. This is particularly important in applications where the motor is holding a vertical load. The delay allows the brake to apply before the bridge is disabled or for the brake to release after the bridge is enabled. You may configure events to activate the brake output from within [“Event Manager” on page 48](#).



Note

In order for the delay to work, you must select 'Apply Brake then Disable Bridge' or 'Apply Brake then Dynamic Brake' within the advanced window of Event Manager.

Stop When active, this field sets the deceleration limit for all stop actions and direction stops. If the drive is controlling velocity or position, the load decelerates according to the user-defined deceleration limit. If the drive is controlling current, the drive will command zero current with no deceleration control. Events that trigger the Stop function can be configured in Event Manager.



Notice

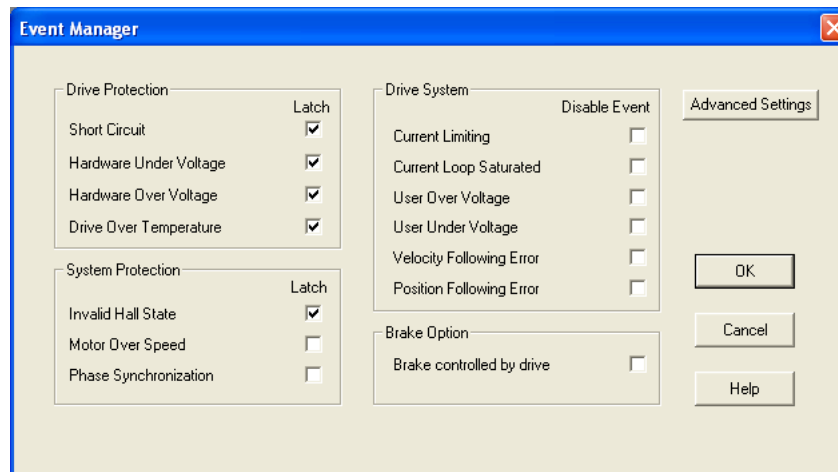
In the deceleration limit text field, be sure to use deceleration values that are realistic and physically possible given the system constraints. If you try to use limits that are not physically possible, the motor may move unpredictably during the deceleration period. For example, the more inertia a motor has, the longer it will take to stop.

Event Manager

The Event Manager window lets you set which event the drive will react to and how it will react to them. You can select handling for drive protection and system protection and drive system events.



Open the window by clicking on the Event Manager button in the Block Diagram



Event Manager Window

- **Latch:** This option is available for the *drive protection* and *system protection* events. If the latch box is checked, the bridge will be disabled and remain disabled until the event is removed or you perform one of these actions:
 - Cycle power to the drive
 - Refresh the Drive Status
- **Disable event:** This option is available for *drive system* events. If the Disable Event box is checked, the corresponding event will *not* result in the bridge being disabled, but will disable the actual event.
- **Brake Option:** This option allows a brake to be assigned with an event action. The brake can be assigned to a digital output in the Inputs / Outputs window. In addition, the brake output can be configured to use delays between external braking and enabling/inhibiting the drive. This delay is designed to prevent loads from falling or coasting when the effects of gravity or other external forces are seen in the system. This may be configured in the Limits & Options window. Checking or unchecking the *Brake controlled by drive* checkbox may result in certain event actions changing. Look in the advanced

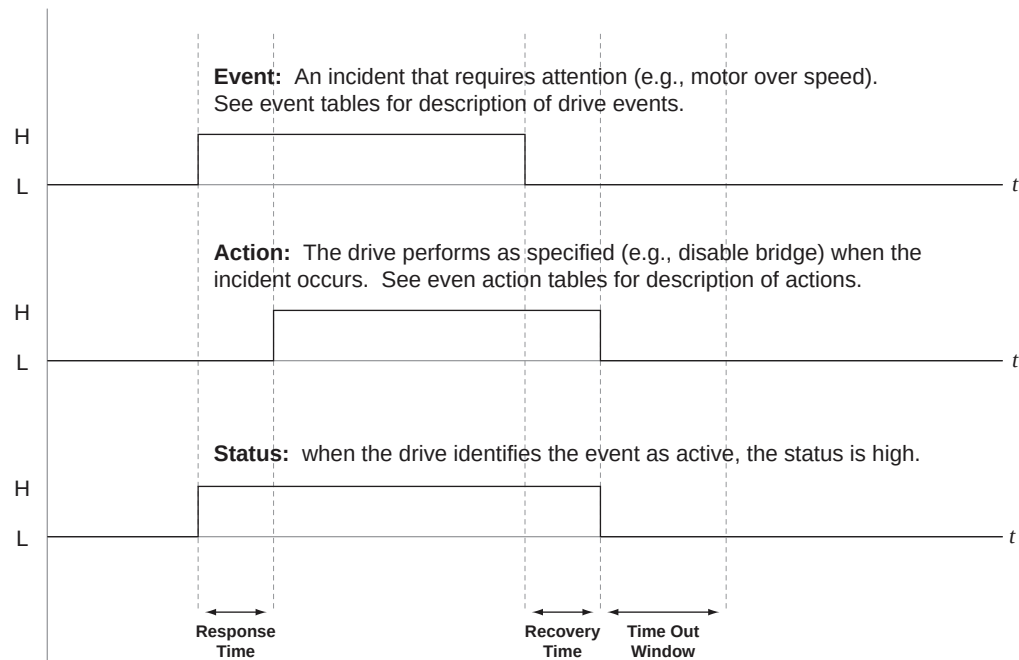
settings window to view the assignments. The following event actions will be affected:

— Checked

Initial Assigned Action	Resulting Assigned Action
Disable Bridge	Apply Brake AND Disable Bridge
Dynamic Brake	Apply Brake then Dynamic Brake
All Other Actions	No Change

— Unchecked

Initial Assigned Action	Resulting Assigned Action
Apply Brake AND Disable Bridge	Disable Bridge
Apply Brake then Disable Bridge	Disable Bridge
Apply Brake then Dynamic Brake	Dynamic Brake
All Other Actions	No Change



Event Action Attributes

If you need to refine the control, there is an Advanced Settings button that accesses other parameters. Events under Advanced Settings can correspond to a fault, or a particular internal drive state.

The events for *System Protection* and *Drive System* have several programmable attributes:

- **Disable:** the event handling can be disabled.
- **Response Time:** the time delay between the actual occurrence of the event and the event action.
- **Event Action:** the action to be taken by the drive after the response time has elapsed. The table below shows the possible actions to choose from. For safety reasons some actions are not available with some events.
- **Recovery Time:** the time after which the selected event action will be removed when the cause of the event is no longer present.
- **Time-Out:** the time, after the recovery time and subsequent removal of the event action, during which the drive will NOT consider an occurrence of the event as a new occurrence. The Event Action will still be applied in case an event does occur within this window. However, that occurrence will not be counted as a new occurrence with regard to the Maximum Recoveries attribute.
- **Maximum Recoveries:** the maximum number of occurrences of the event prior to a permanent event action.

- **Unlimited Recoveries:** there is no limit to the number of occurrences of the event.
- **Automatic CanOpen Fault Recovery:** This option is available only for CANopen drives. When checked, the drive will allow the CANopen state machine to automatically sequence from fault to enabled state as if it were a stand-alone drive. If unchecked, the CANopen state machine will override the event manager settings, and you will be required to send CAN commands in order to recover from faults.

Event Action	Description
No Action	Event Action is disabled
Disable Power Bridge	No power is delivered to the motor. Motor is allowed to move freely.
Disable Positive Direction	Disables the drive from outputting to the motor in the positive direction, while allowing commanded motion in the negative direction. The result is dependent on the mode of operation. This action is not recommended in vertical applications because the load will be free to fall once the limit is activated. For vertical loads, we recommend using 'Positive Stop'.
Disable Negative Direction	Disables the drive from outputting to the motor in the negative direction, while allowing commanded motion in the positive direction. The result is dependent on the mode of operation.
Dynamic Brake	Motor leads are virtually shorted together internally. However, the bridge enables to protect motor by regulating motor current.
Positive Stop	If the drive is controlling velocity or position, the load decelerates according to the deceleration limit specified in Limits & Options. If the drive is controlling current, the drive will command zero current with no deceleration control. Commanded motion in the in the positive direction has no affect. Motor continues to servo with zero command in the positive direction.
Negative Stop	If the drive is controlling velocity or position, the load decelerates according to the deceleration limit specified in Limits & Options. If the drive is controlling current, the drive will command zero current with no deceleration control. Commanded motion in the in the negative direction has no affect. Motor continues to servo with zero command in the negative direction.
Stop	If the drive is controlling velocity or position, the load decelerates according to the deceleration limit specified in Limits & Options. Commanded motion has no affect. Motor continues to servo with zero command.
Apply Brake then Disable Bridge	Brake output is turned on, and then the bridge is disabled. The delay is set in Limits & Options.
Apply Brake then Dynamic Brake	Brake output is turned on, and then the dynamic brake is applied. The delay is set in Limits & Options.

Some of the above mentioned attributes are not programmable for certain events.

Drive Protection Tab

Event	Response Time (ms)	Event Action	Recovery Time (ms)	Time-Out (ms)	Maximum Recoveries	Unlimited
Short Circuit	0	Disable Power Bridge	500	5	0	☐
Hardware Under Voltage	0	Disable Power Bridge	100	20	0	☐
Hardware Over Voltage	0	Disable Power Bridge	100	20	0	☐
Drive Over Temperature	0	Disable Power Bridge	1000	10	0	☐
Drive Internal Error	0	Disable Power Bridge	0	0	0	☐
Drive Reset	0	Disable Power Bridge	200	0	1	☐
Over Current	0	Disable Power Bridge	5	10	0	☐

☐ Automatic CanOpen Fault Recovery

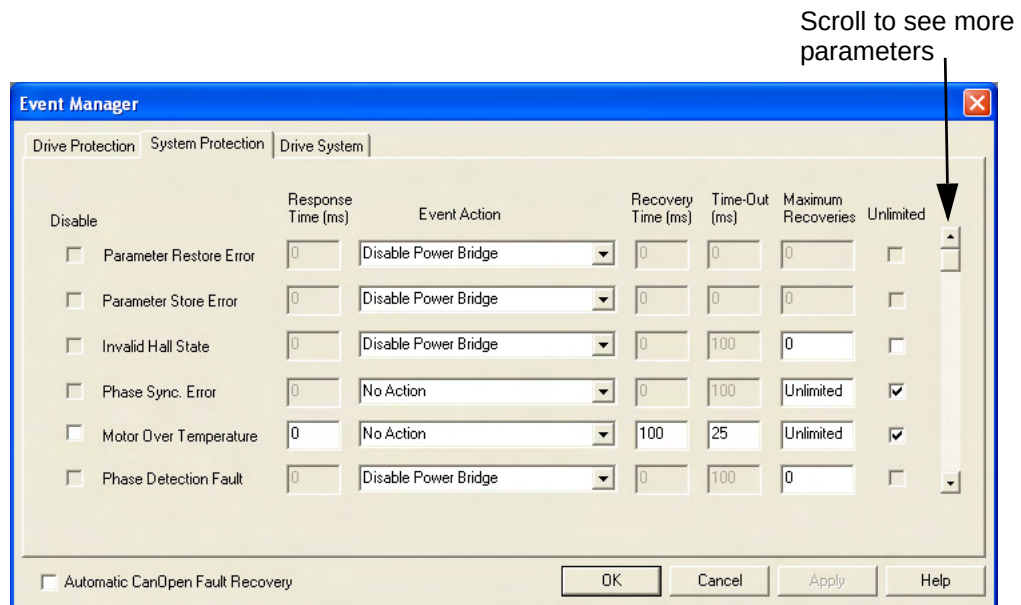
OK Cancel Apply Help

Event Manager, Drive Protection tab

These internal faults and states apply to drive protection:

Event	Description
Short Circuit	Short-circuit condition of the power output stage
Hardware Under Voltage	DC bus voltage below the drive hardware under voltage limit.
Hardware Over Voltage	DC bus voltage above the drive hardware over voltage limit.
Drive Over Temperature	Drive internal temperature exceeded the maximum drive temperature limit.
Drive Internal Error	Checksum error of the drive run-time firmware.
Drive Reset	Indicates that the drive powered up in a disabled state. This occurs each time the drive is reset.
Over Current	The drive output current has exceeded the maximum drive rating.

System Protection Tab



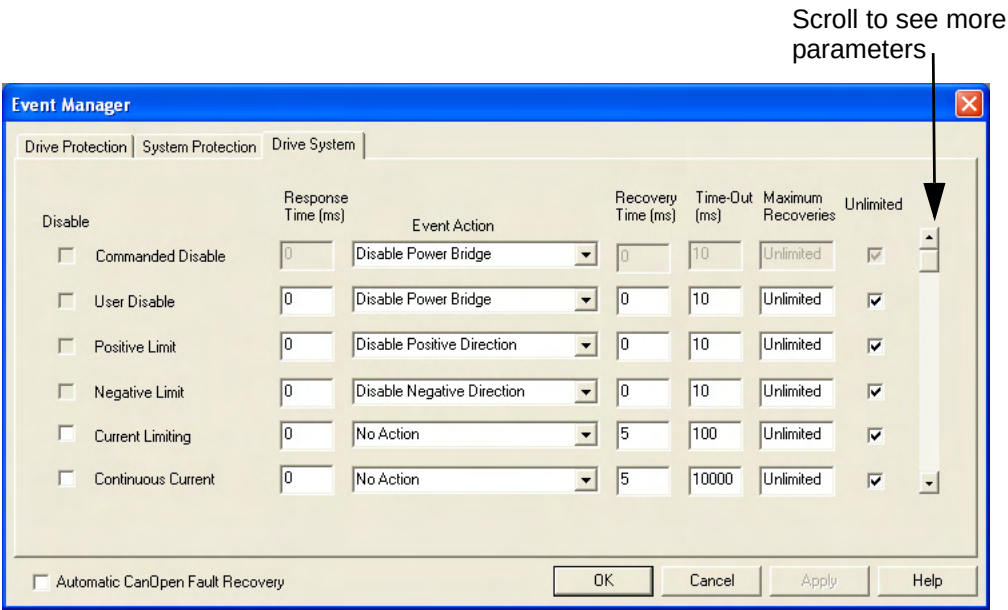
Event Manager, System Protection tab

These errors detected by the drive apply to system protection.

Event	Description
Parameter Restore Error	An error during parameter download from non-volatile memory.
Parameter Store Error	An error during parameter upload to non-volatile memory.
Invalid Hall State	An invalid state of the hall sensors has been detected.
Phase Synchronization Error	A synchronization loss due to a missing Hall sensor or encoder index edge has occurred.
Motor Over Temperature	Applicable only when a motor temperature sensor is connected to a programmable input (analog or digital) with the Motor Over Temperature function. The event corresponds to this input becoming active.
Phase Detection Fault	The phase detection algorithm did not properly complete.
Feedback Sensor Error	A feedback sensor error (e.g. missing encoder, bad resolver, etc.) has occurred
Motor Over Speed	The measured motor velocity has exceeded the motor over speed limit.
Max Measured Position	The measured position has exceeded the Max Measured Position limit.

Event	Description
Min Measured Position	The measured position has exceeded the Min Measured Position limit.
Comm. Channel Error	Error during communication between drive and PC. Used exclusively with CANopen drives. This event is triggered by failure to receive a node-guard message within the specified life time of the drive. Also triggers when more than 35 minutes ($2^{31} \mu s$) has elapsed between consecutive time stamps. See CANopen manual for more information on Node Guarding, Life Guarding, and time stamps.
PWM Input Broken Wire	The drive has detected a broken wire on the input signal while set up for PWM and Direction input.

Drive SystemTab



Event Manager, Drive System Tab

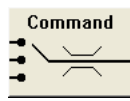
These internal drive states apply to system status (they do not necessarily correspond to a drive fault status, but could related to a system error).

Event	Description
Commanded Disable	An disable command over the communications interface (active when the stop light icon is red).
User Disable	An disable command from a digital input.
Positive Limit	A positive limit command from a digital input.
Negative Limit	A negative limit command from a digital input.
Current Limiting	The drive is commencing current limiting (based on the current limit settings).
Continuous Current	The drive has reached the continuous current setting, after current limiting.
Current Loop Saturated	The maximum PWM duty cycle has been reached due to current loop saturation.
User Under Voltage	DC bus voltage below the User Under Voltage Limit setting (see Drive Configuration).
User Over Voltage	DC bus voltage above the User Over Voltage Limit setting (see Drive Configuration).

Event	Description
Non-sinusoidal Commutation	The drive is not commutating sinusoidally. This event occurs automatically upon power-up before the motor has moved around. Otherwise, this may be due to loss of synchronization or saturation, or the drive may be set for trapezoidal commutation.
Phase Detection Active	The drive is going into phase detection mode (phasing based on the encoder only feedback).
User Aux Disable	This event can be assigned to a digital input. It is meant to allow for an alternative action to that assigned to the "User Disable" event. For example, you may assign Inhibit Bridge to the User Inhibit event, and also assign Dynamic Brake to the User Aux Disable event.
Shunt Regulator	DC bus voltage above the Shunt Turn-on Voltage setting (see Drive Configuration). Effective only on drive models with built-in shunt regulator.
Zero Velocity	The measured motor velocity is within the Zero Velocity window as defined in Limits and Options.
At Command	The measured motor velocity has reached the target velocity, within the At Velocity Window (found in Limits & Options).
Velocity Following Error	The velocity following error exceeds the Velocity Following Error window.
Positive Target Velocity	The demand velocity has reached the Positive Velocity limit.
Negative Target Velocity	The demand velocity has reached the Negative Velocity limit
Phase Detection Complete	The phase detection algorithm is complete.
Position Following Error	The position following error has exceeded the Position Following Error limit.
Max Target Position	The demand position has reached the Max Target Position limit.
Min Target Position	The demand position has reached the Min Target Position limit.
Load Target	The target value has been replaced with the predefined target position.
Homing active	Homing is being performed.
PVT Buffer Full	Full The PVT buffer cannot accept any more information.
PVT Buffer Empty	The PVT buffer contains no more information
PVT Buffer Threshold	The PVT threshold has been reached as defined in the PVT command type window.
PVT Buffer Failure	An error has occurred while retrieving PVT information from the buffer.
PVT Buffer Empty Stop	The PVT buffer has run out before a valid PVT stop point was sent.

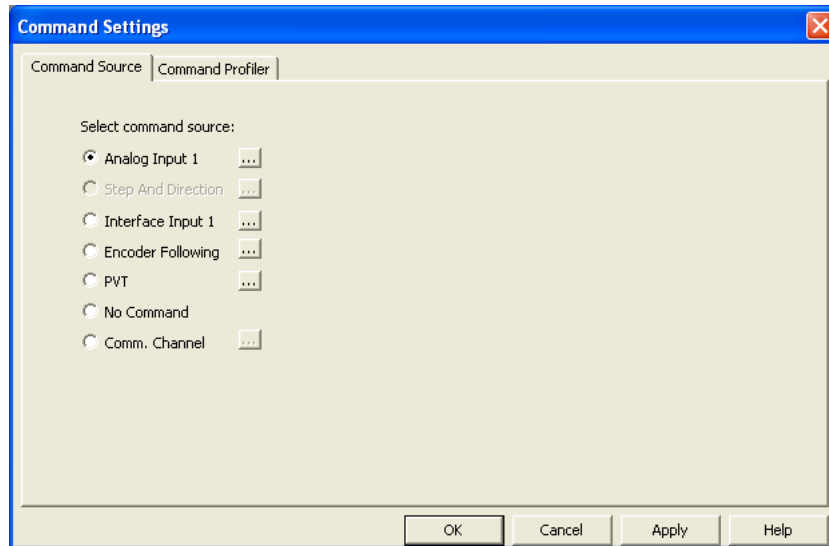
Event	Description
PVT Sequence Number	PVT trajectory points were received out of order (can indicate a missing PVT point or repeated point).
Homing complete	Homing has finished.
Commanded Quick Stop	A quick stop event via the communication interface.
User Quick Stop	A quick stop event via a digital input.
Commanded Positive Limit	A positive limit command from the communications interface.
Commanded Negative Limit	A negative limit command from the communications interface.

Command Settings Window

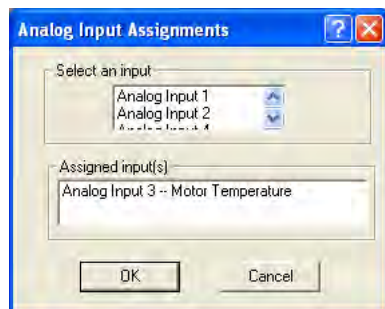


The Command Source window can be opened by clicking on the command source block in the main block diagram. It allows selection and configuration of the command source.

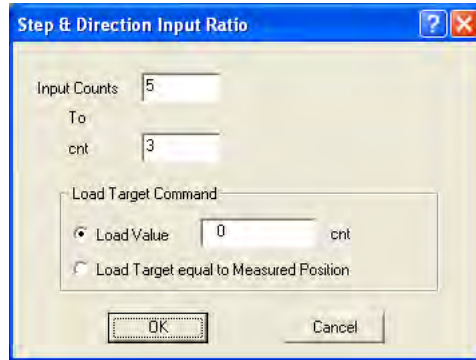
Command Source Tab



Analog input Selects an analog input as the command source for the drive. Configuration of this input can be done in the I/O Configuration window. The ellipses ... button displays analog input assignments. All analog inputs are shown. If more than one is available, you may select it from the Select an input box. You may not select an input shown in the Assigned input(s) box because it is assigned to another task.



Step and Direction Selects the step and direction inputs (see hardware manual or data sheet) to control the motor in a simulated stepper motor configuration. Click on the ellipses  button to show the window.



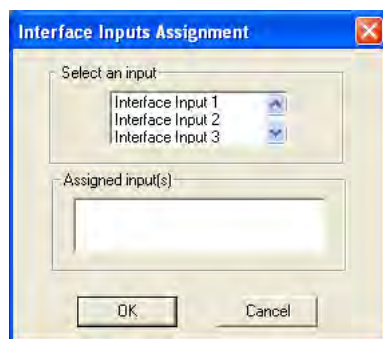
Input Counts are the number of input pulses desired to move the motor by a given amount, defined in the second entry field.

Conversion varies with the selected mode; for example, input counts to amps for current, input counts to speed units for velocity, and input counts to position units for position.

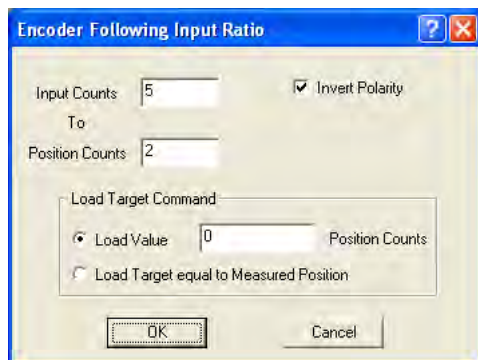
The number entered in either field must be between 1 and 65535.

The *Load Target Command* specifies what occurs when you activate a *Load Target* command via a digital input. You may choose the drive to load a specified set-point into the commanded target, or (for position mode) you may choose the drive to set the target position equal to the currently measured position. Be aware that the first option may cause the motor to jump to the specified target when activated.

Interface input For internal use. Click on the ellipses  button to show the window.



Encoder following Selects the secondary encoder input (see hardware manual or data sheet) to drive the motor in a master/slave configuration. Click on the ellipses  button to bring up the window.



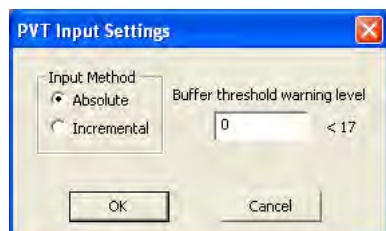
Input Counts are the number of quadrature input pulses desired to move the motor by a given number of counts. *Position Counts* are the number of counts desired to move for the given input counts.

- If using an encoder for primary feedback, *Position Counts* represents the number of encoder counts to move.
- If using a resolver for primary feedback, *Position Counts* represents the number of resolver counts as determined by the specified resolver resolution.

The *Invert Polarity* checkbox changes the resulting motor direction for a given input command.

The *Load Target Command* specifies what occurs when you activate a *Load Target* command via a digital input. You may choose the drive to load a specified count into the position target, or you may choose the drive to set the target position equal to the currently measured position. Be aware that the first option may cause the motor to jump to the new target position when activated.

PVT Selects PVT as the control mode. For more information on PVT including absolute versus incremental input methods, see [“PVT Generator” on page 119](#). Click the ellipses  button to bring up the window.



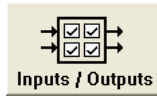
The PVT input method window allows you to select between Absolute and incremental PVT points. It also allows you to define the buffer level at which a buffer threshold warning will occur.

No command This assigns no command source to the drive. Typically, No Command will be automatically assigned when major control loop changes are performed. This is a protection feature to minimize sudden motor movement.

Comm. channel This command will automatically be assigned when the drive is being controlled by an outside source. This capability is available with network interface products.

Inputs / Outputs

The I/O Configuration window allows configuration and diagnostics of all digital and analog programmable inputs and outputs.



You can access this window by clicking on the I/O icon on the main screen.

The following tabs are available:

- Analog Inputs
- Analog Outputs
- Digital Inputs
- Digital Outputs
- Capture Inputs

Analog Inputs Tab

I/O Configuration

Analog Inputs | Analog Outputs | Digital Inputs | Digital Outputs | Capture Inputs

Analog Input 1
Not Assigned 1.00 Offset: 0.0000 V
Value: 0.04 V Deadband ± mV

Analog Input 2
Not Assigned 1.00 Offset: 0.0000 V
Value: 0.07 V Deadband ± mV

Analog Input 3
Not Assigned 1.00 Offset: 0.0000 V
Value: 0.02 V Deadband ± mV

Analog Input 4
Not Assigned 1.00 Offset: 0.0000 V
Value: -0.08 V Deadband ± mV

OK Cancel Apply Help

Each programmable analog input can be assigned a certain drive function. Assignment of these functions can be made in the Command or Feedback window. Each input can also be scaled, according to the selected function, to provide an optimal range. Entering the numerical value of the chosen function for a 1V input signal performs the scaling. An offset (in volts) can also be defined.

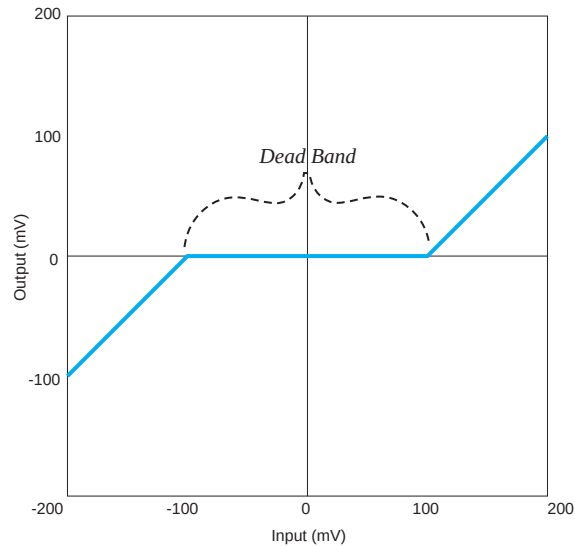
Check the drive data sheet to find the number of available analog inputs.



Note

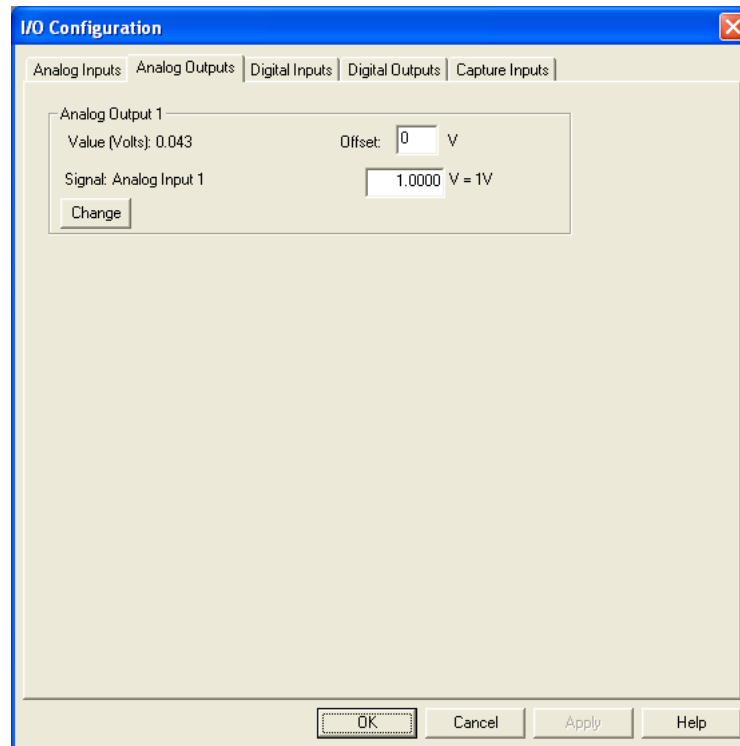
Selections become effective after clicking the Apply or OK button.

A programmable deadband can be configured for analog inputs assigned to the command source. The deadband allows a voltage range which will have no affect on the command. This is particularly useful when the analog command source is configured to control velocity.



The drive handles anything within the deadband range as zero, and subtracts the dead band value from all other values. For example, with a dead band setting of ± 100 mV, the amplifier ignores any signal between -100 mV and +100 mV.

Analog Outputs Tab



Each programmable analog output can be assigned to a certain drive variable.

Each output can also be scaled, according to the selected variable, to provide an optimal range. Entering the numerical value of the chosen variable for a 1V output signal performs the scaling.

An offset (in volts) can also be defined.



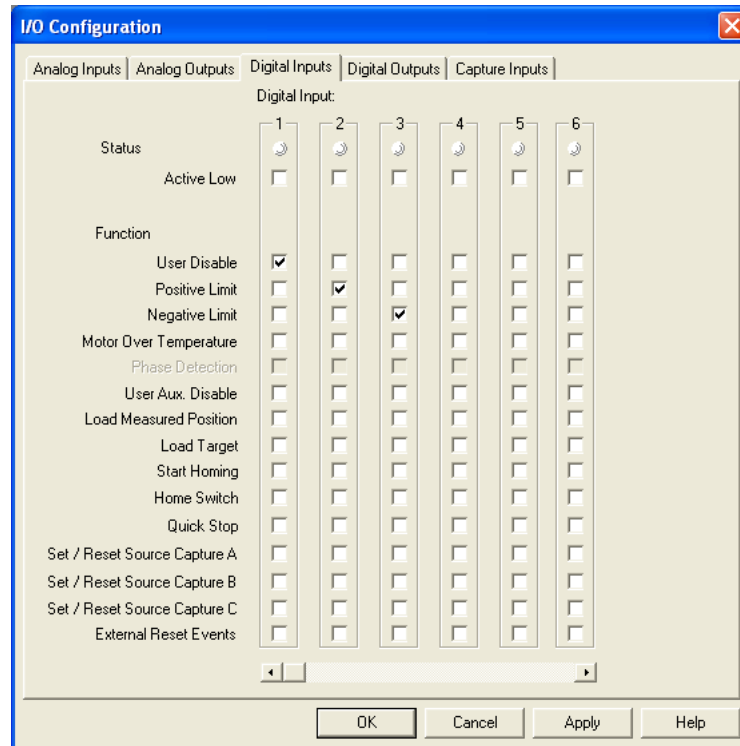
Note

Selections become effective after clicking the Apply or OK button.

Check the drive data sheet to find the number of available analog outputs.

A list of available output signals and their definitions can be found in [“Signal Definitions” on page 129](#).

Digital Inputs Tab



The present status of each input is displayed by the LED graphic below each Digital Input number (gray= Not Active, green= Active). The Active Low checkmark determines the input polarity. Active low means the input must be pulled-down for the input to be considered ON.

Each input can be assigned to one or more functions via the checkmark matrix. If more than one function is assigned to a single input, the following priority rules apply (from highest to lowest):

1. Inhibit
2. Dynamic brake
3. Positive or negative limit
4. Phase Detection

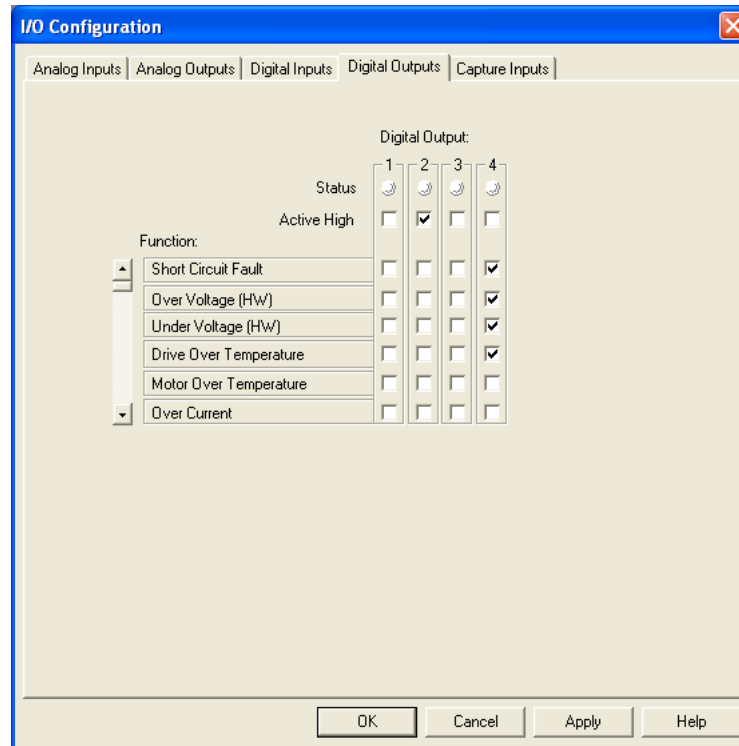
The User Disable, User Aux Disable, and the Motor Over Temperature functions depend on the selected function in the Event Manager window.



Note

Selections become effective after clicking the Apply or OK button.

Digital Outputs Tab



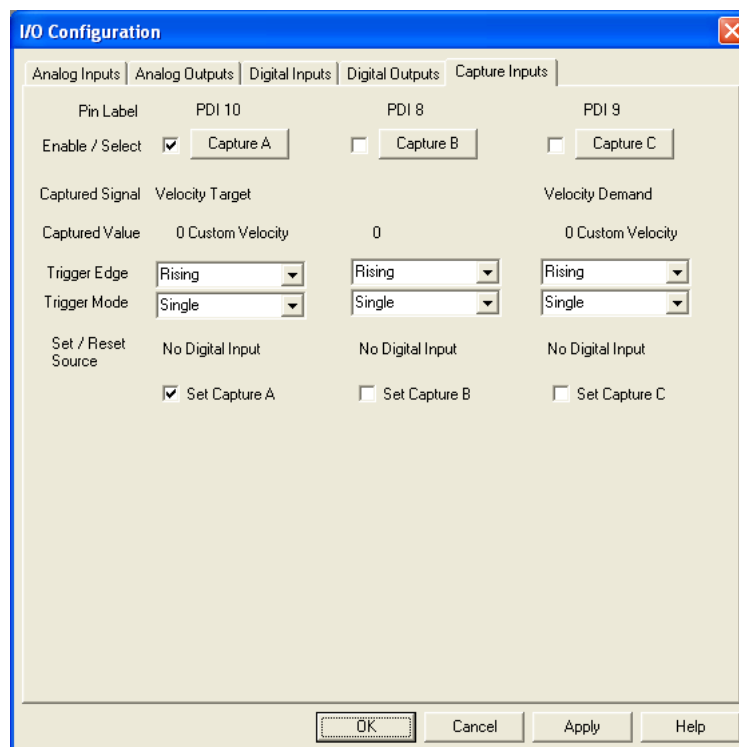
The present status of each output is displayed by the LED graphic below each Digital Output number (gray= Not Active, green=Active). The Active High checkmark determines the output polarity. Active High means the output is pulled-down if the output is considered OFF. Each output can be assigned one or more functions via the checkmark matrix. If more than one function is assigned to a single output, the functions are OR-ed, which means that if one of the functions is true, the output will be turned ON.



Note

Selections become effective after clicking the Apply or OK button.

Capture Inputs Tab



The image shows a screenshot of the 'I/O Configuration' dialog box, specifically the 'Capture Inputs' tab. The dialog has a blue title bar with a close button. Below the title bar are five tabs: 'Analog Inputs', 'Analog Outputs', 'Digital Inputs', 'Digital Outputs', and 'Capture Inputs'. The 'Capture Inputs' tab is selected. The main area of the dialog is divided into three columns for 'PDI 10', 'PDI 8', and 'PDI 9'. Each column has a 'Pin Label' row, an 'Enable / Select' row with a checkbox and a button, a 'Captured Signal' row, a 'Captured Value' row, a 'Trigger Edge' dropdown menu, a 'Trigger Mode' dropdown menu, a 'Set / Reset Source' row, and a 'Set' checkbox. For PDI 10, the 'Enable / Select' checkbox is checked, the button is 'Capture A', the 'Captured Signal' is 'Velocity Target', the 'Captured Value' is '0 Custom Velocity', the 'Trigger Edge' is 'Rising', the 'Trigger Mode' is 'Single', the 'Set / Reset Source' is 'No Digital Input', and the 'Set' checkbox is checked. For PDI 8, the 'Enable / Select' checkbox is unchecked, the button is 'Capture B', the 'Captured Signal' is 'Velocity Demand', the 'Captured Value' is '0', the 'Trigger Edge' is 'Rising', the 'Trigger Mode' is 'Single', the 'Set / Reset Source' is 'No Digital Input', and the 'Set' checkbox is unchecked. For PDI 9, the 'Enable / Select' checkbox is unchecked, the button is 'Capture C', the 'Captured Signal' is 'Velocity Demand', the 'Captured Value' is '0 Custom Velocity', the 'Trigger Edge' is 'Rising', the 'Trigger Mode' is 'Single', the 'Set / Reset Source' is 'No Digital Input', and the 'Set' checkbox is unchecked. At the bottom of the dialog are four buttons: 'OK', 'Cancel', 'Apply', and 'Help'.

Pin Label	PDI 10	PDI 8	PDI 9
Enable / Select	☒ Capture A	☐ Capture B	☐ Capture C
Captured Signal	Velocity Target	Velocity Demand	Velocity Demand
Captured Value	0 Custom Velocity	0	0 Custom Velocity
Trigger Edge	Rising	Rising	Rising
Trigger Mode	Single	Single	Single
Set / Reset Source	No Digital Input	No Digital Input	No Digital Input
Set	☒ Set Capture A	☐ Set Capture B	☐ Set Capture C

You can capture internal signals instantly on the occurrence of a designated input transition. You can capture on a rising edge, falling edge, or both.

Capture Inputs tab fields include:

Pin Label	This shows the label specified for the capture. See the drive data sheet for the specific pin number associated with the label.
Enable/Select	The checkbox allows you to enable the specified capture input. When you click on the capture button next to the check box, you can set which signal you would like to capture.
Captured Signal	This field shows the selected signal to be captured.
Captured Value	This shows the last value captured by the drive.
Trigger Edge	You may select between rising, falling, or both to set when the signal will be captured.
Trigger Mode	Single mode will allow the signal to be captured only once per set/reset. Continuous will allow the signal to be captured any time it is triggered while capture is set.
Set / Reset Source	This provides a list of available sources for turning on or resetting the capture.
Set Capture checkbox	While in the configuration software, the checkbox can be used instead of a digital input to turn on or off the capture functionality.

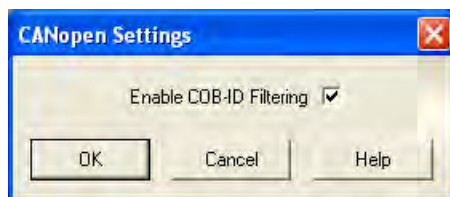
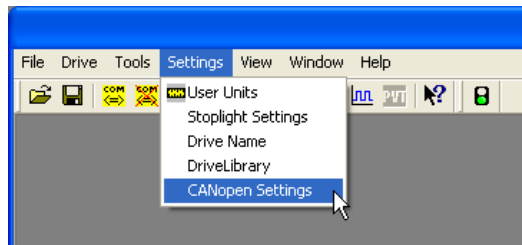


Notice

You may not use the same digital input for capture and command source.

CANopen Settings

The CANopen Settings window is available for drives which support CANopen communications. This window allows for configuring COB-ID filtering. When COB-ID filtering is turned on, the drive will not monitor CANopen messages which are meant for other nodes. This results in faster overall message handling. It is recommended to have COB-ID filtering enabled when applicable.



Note

When COB-ID filtering is enabled, PDOs cannot be configured while the drive is in the operation enabled state.

4 Tuning and Commutation

Before proceeding, you must accomplish the following actions:

- ☐ Configure the limits and options parameters.
- ☐ Connect the motor power and feedback.

Drive tuning is a multi-step process that involves proper tuning of up to three different servo loops. Before tuning, the drive should have the appropriate parameters and limits configured as per the ["Limits & Options" on page 37](#). Following are the summary tasks you must perform; later in this chapter you will find the actual procedures with individual steps.



Caution

Sudden motion may occur! Tuning should only be performed after you have specified motor information and drive limits. See Configuration Wizard if you are not sure your drive is configured correctly for tuning.

- 1. Current Loop Tuning:** Once the drive parameters are configured properly, the current loop must be tuned. This is the innermost loop and forms the basis of all motion. You can select to have the current loop gains calculated based on motor and application data. This will typically provide a good starting point although some applications may require further refinement of the tuning parameters.



Notice

Make sure the drive is disabled before selecting Calculate Gains.



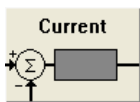
2. **AutoCommutation™ Detection:** This routine collects data on the motor and feedback parameters and asks the user to verify that they match what is entered into the Motor Data page. Some applications may have motors that cannot perform this routine due to mechanical constraints. It is possible to manually wire a motor for commutation. See ["Manual Commutation Procedure" on page 85](#) if you must perform manual commutation.



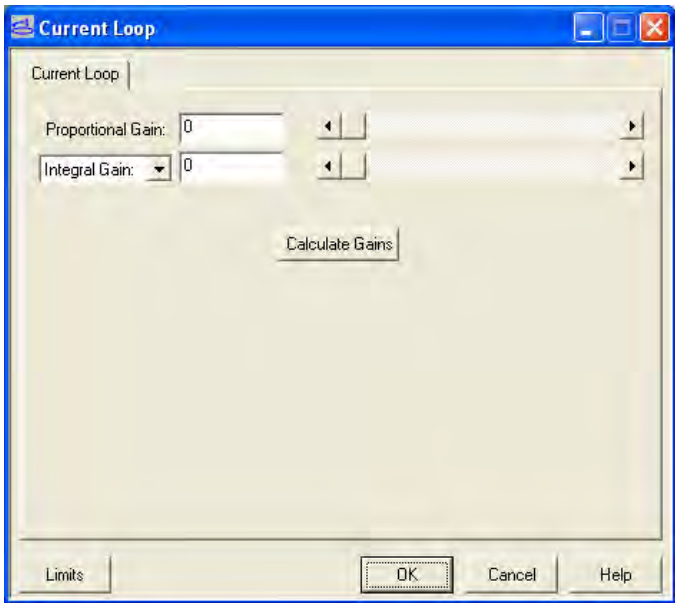
It is crucial to make sure the motor is unloaded; any load applied to the motor will skew the results of the routine

3. **Velocity Loop Tuning:** If you want to operate the drive in velocity mode, you must tune the current loop and set up the drive to commute the motor (steps 1 and 2). A very tight current loop inside of a relatively tight velocity loop may cause audible noise. If maximum bandwidth is not necessary, de-tuning the current loop usually removes most of the audible noise. The velocity loop will have to be adjusted any time the current loop tuning is changed.
4. **Position Loop Tuning:** You can either tune the position loop around the velocity loop, or around the current loop. Generally, it is much easier to tune a position loop around a velocity loop because only the proportional gain is needed. When tuning position around the current loop, a high derivative gain may be necessary on top of both proportional and integral gains.

Current Loop Tuning



Open the Current Loop window by clicking on the Current Loop icon in the main block diagram. The Current Loop tab in this window shows the available current loop parameters.



Two options for current loop parameter settings are available

Proportional and Integral Gain	Set according to conventional PI tuning rules. See Tuning for more information.
Proportional Gain and Motor Pole	Use for zero-placement in the current loop algorithm. The proportional gain setting is the overall gain of the current loop algorithm. When the Motor Pole value matches the actual motor electrical pole (the inverse of the motor electrical time constant), a critically damped response can be obtained with the largest overall proportional gain.

The current loop parameters can be entered in the edit boxes or set via the slider bars. The values take effect immediately, but will only be saved if the OK button is clicked.

The Calculate Gains button will calculate the current loop parameters based on the motor and application data entered in the windows for Motor and Feedback Data and Limits & Options. Make sure proper motor and application data are entered prior to using this function. Specifically, be sure the motor inductance, resistance, and nominal bus voltage are entered correctly.

The Limits button opens the Limits and Options --> Drive Current Limits window.

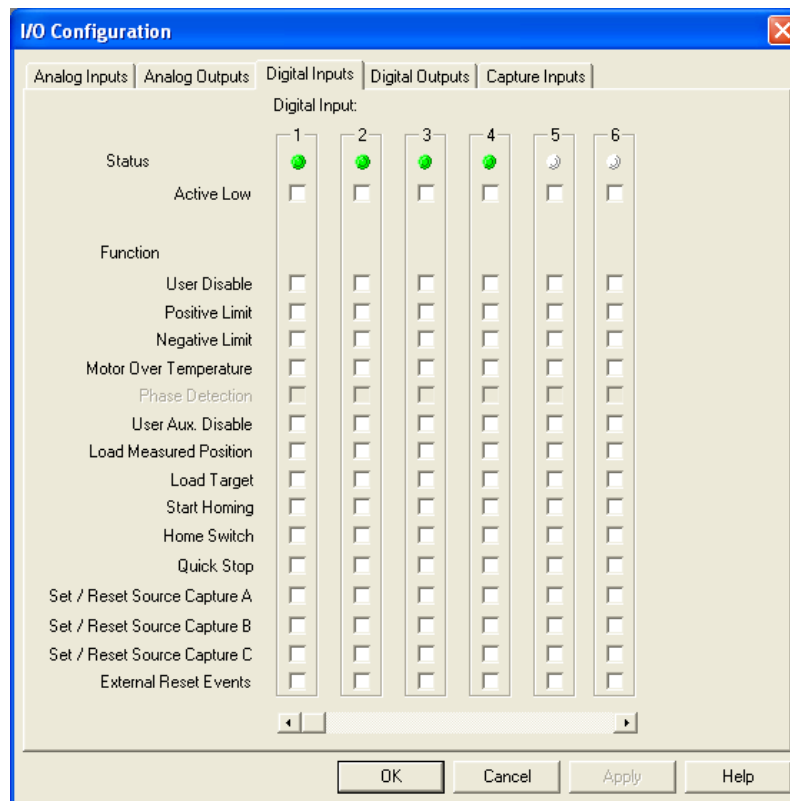
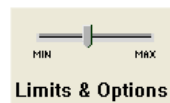


Notice

Make sure that the motor is free to move and de-coupled from the load. Sudden motion may occur! You must specify the motor information and drive limits before tuning the current loop.

Step 1: I/O Configuration setup

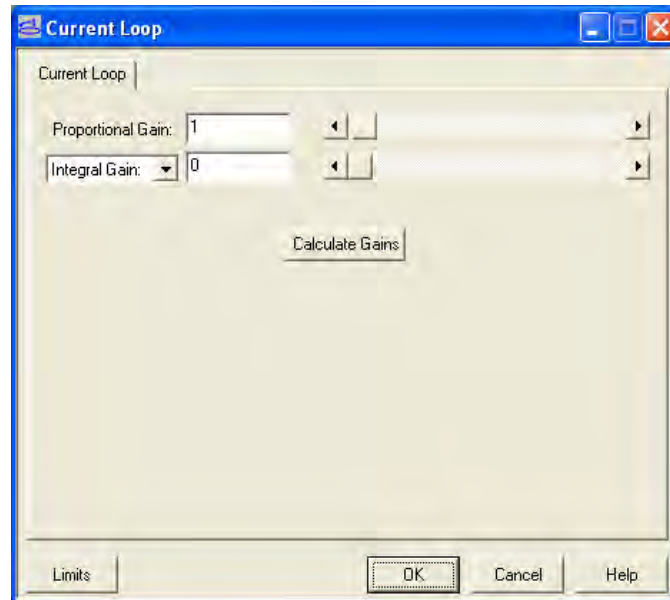
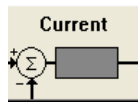
1. Click the I/O Configuration Block in the main block diagram.
2. Select the Digital inputs tab.



3. If an external Inhibit/Enable circuit is used during setup, use the check boxes to assign the inhibit function and proper polarity (e.g., active high or active low).
4. If no external Inhibit/Enable circuit is used during setup, clear check boxes for all inhibits. Inhibit/Enable will be controlled solely through the Enable/Disable Drive icon .

Step 2: Current Loop window setup

1. On the Main Block Diagram, click Current Loop to open the current loop tuning parameters.



2. To set starting values for proportional and integral gains, click the Calculate Gains button.

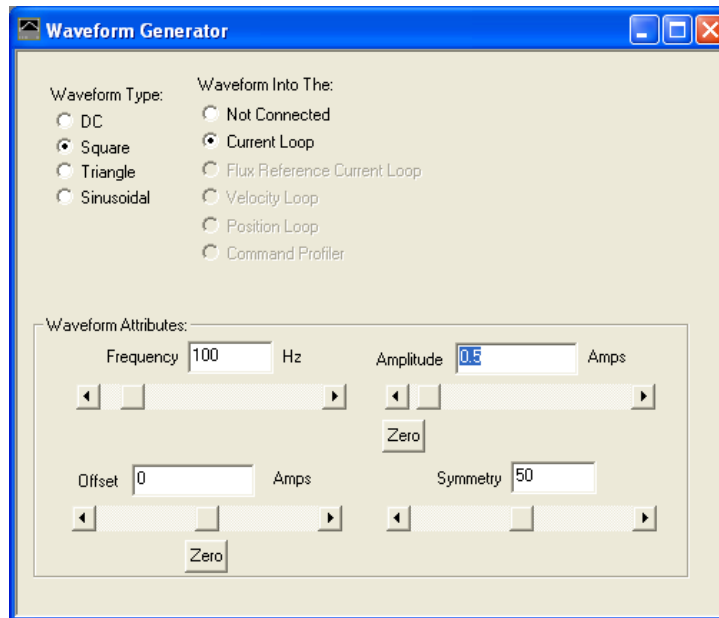


Note

Calculate Gains utilizes the values entered into the Motor and Feedback Data and Limits & Options screens. The specified inductance, resistance, and bus voltage determine accuracy of the calculated values. If accurate data are not available, begin with the Proportional Gain = 1 and Integral Gain = 0.

Step 3: Waveform Generator setup To open the Waveform Generator window, do one of the following:

- Select Tools > Waveform Generator on the main menu bar.
- Click the Waveform Generator icon  on the tool bar.

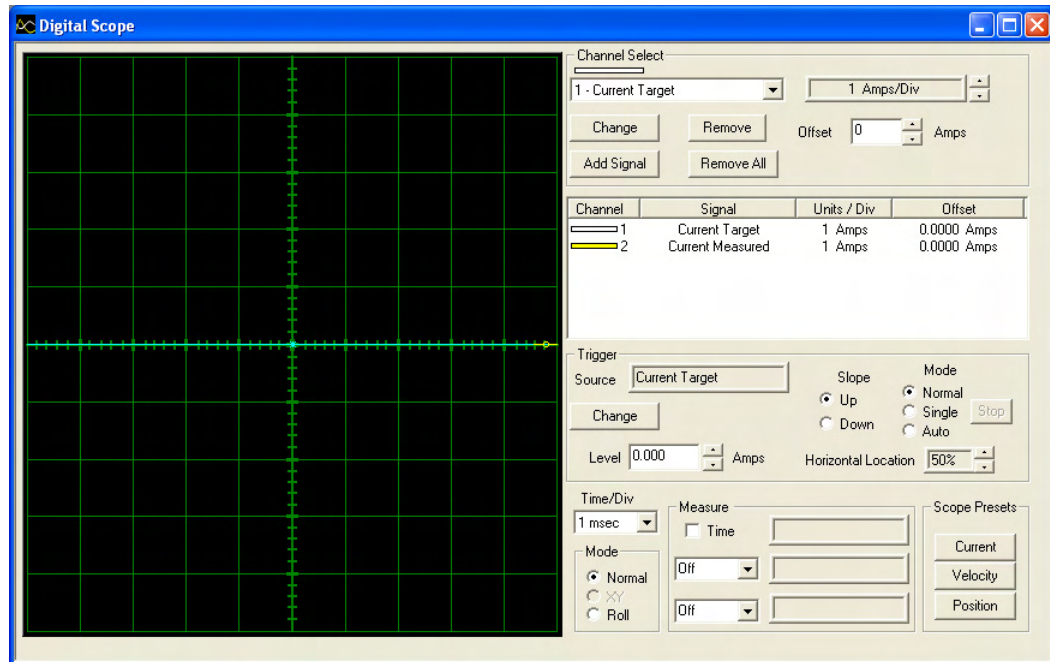


Set up the Waveform Generator as follows:

1. Select the *Square* Waveform Type.
2. Set *Frequency* to 100 Hz. If your motor has low inertia and is very responsive, use 150 Hz or 200 Hz.
3. Ensure *Offset* is zero.
4. Ensure *Symmetry* is 50%.
5. Select *Waveform Into The Current Loop*.
6. Set the waveform amplitude to an appropriate value. Begin with 10% of the drive continuous rating or 50% of the motor continuous current rating, whichever is lower.

Step 4: Oscilloscope setup To open the Oscilloscope window, do one of the following:

- Select Tools > Oscilloscope on the main menu bar.
- Click the Oscilloscope icon  on the tool bar.

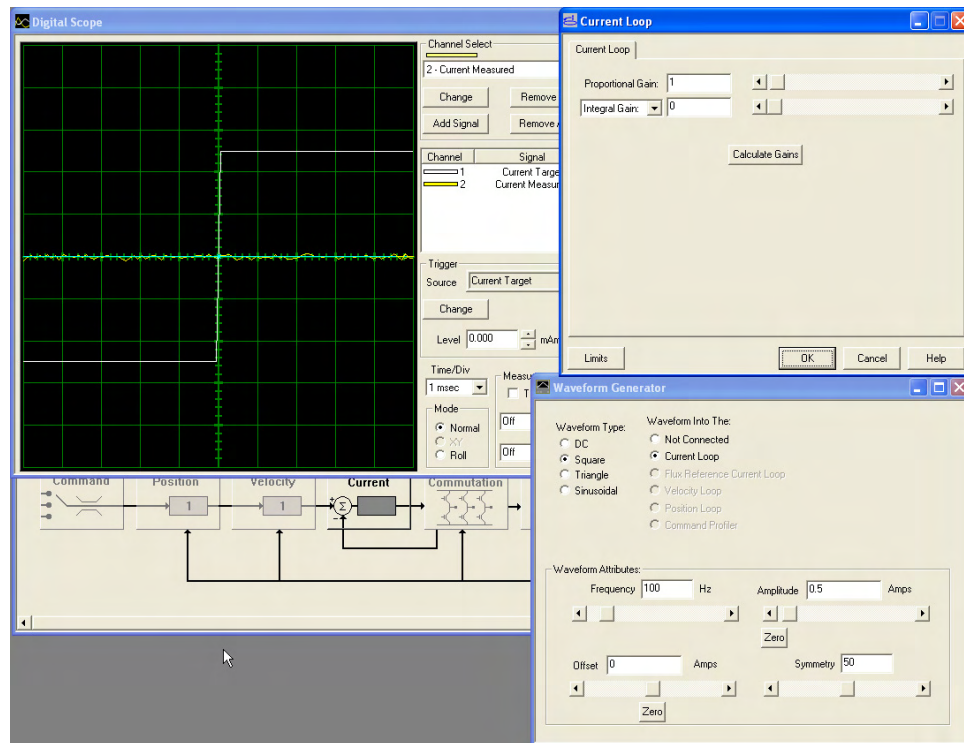


To configure the oscilloscope for current loop tuning, select the "Current" option from the Scope Presets section of the Digital Scope window.

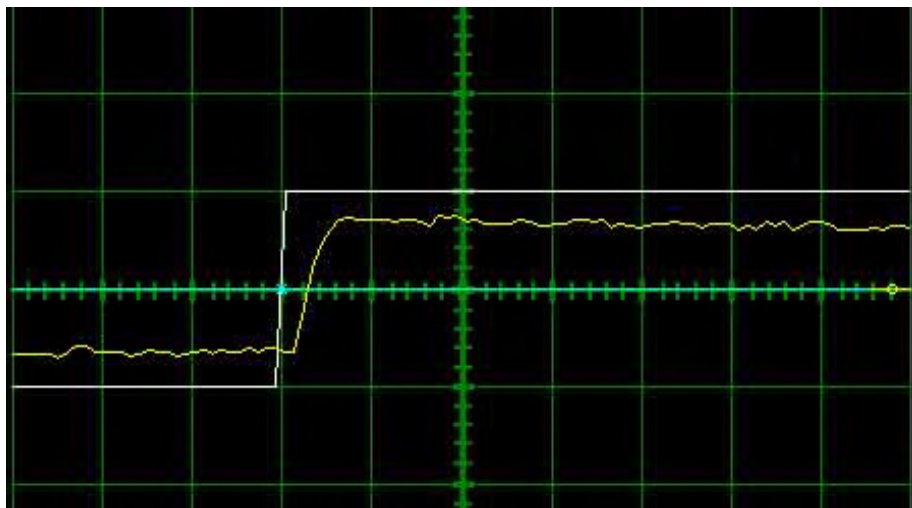
The oscilloscope can also be manually configured for current loop tuning by following these steps:

1. Use the drop down menu to change the channel 1 signal to **Current Target**.
2. Use the drop down menu to change the channel 2 signal to **Current Measured**.
3. Change the Trigger Source to Current Target with the Level set to zero.
4. Ensure Trigger Mode is Normal.
5. Change Time/Div to either 1 msec or 500 μ sec.

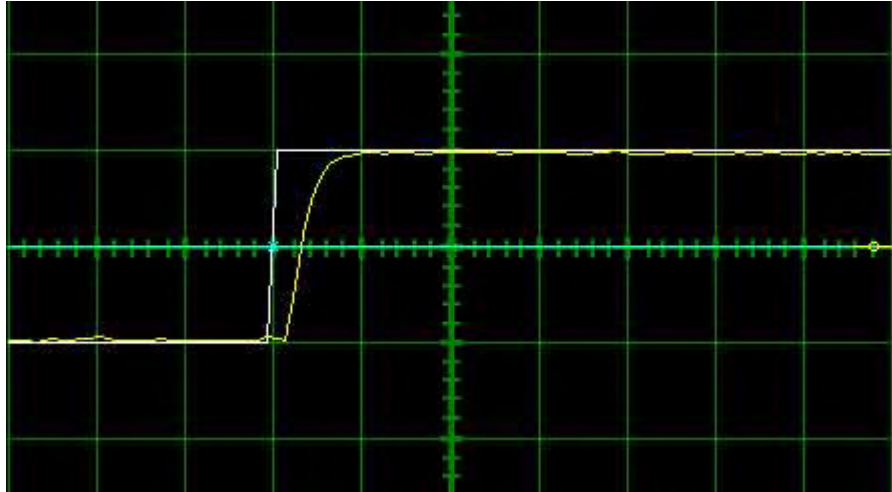
Step 5: Tuning Position the Scope, Waveform Generator, and Current Loop windows such that a majority of all the windows are visible.



- Enable the drive by clicking the Stoplight icon . The motor should emit an audible noise but remain still.
- Proper current loop tuning starts with zero integral gain while increasing the proportional gain until a 'knee' is formed (with no overshoot) in the Current Measured trace.



At this point, the proportional gain is done and the Integral gain must be slowly increased to close the steady state error between the Current Target and Current Measured traces.



Tuning changes with signal amplitude. Therefore you should now re-adjust the current amplitude in the waveform generator according to your most common application current requirements and re-tune. Contouring applications generally use small signal transients while point-to-point applications use larger signal transients.

When current loop gain adjustments are complete:

1. Disable the drive by clicking the Stoplight icon .
2. Click Not Connected on the Waveform Generator to remove the command signal from the drive.
3. Store parameters to the drive's nonvolatile memory. For review, see ["Storing the Changes onto the Drive" on page 14](#).
4. Click "OK" in the Current Loop window to save and close your gain settings.



Reminders

Do not close out of the Current Loop window by selecting the "X" in the upper right corner. Closing out this way will not save your gain settings. You must close out of the Current Loop window by clicking "OK".

For reference, see [Figure B, "Current Limiting," on page 139](#).

Commutation

Motor commutation is dependant on the type of motor and feedback available from the motor. Brushed motors have a commutator built into the motor housing; therefore the drive does not have to be configured to commute them. Brushless DC (Trapezoidal), and AC (Sinusoidal), motors require a correctly configured drive to commute.

Commutation of a permanent magnet servomotor is the process that maintains an optimal angle between the permanent magnet field and the electromagnetic field created by the motor current(s). This process ensures optimal torque or force generation at any motor position, regardless of speed, for brushless motors.

There are two ways to configure a digital drive to commute a motor:

- **AutoCommutation™ Detection:** Most applications can use the AutoCommutation routine for configuring a drive to a specific motor. This routine will detect the feedback devices attached to the motor and ask the user to verify them against the motor's data sheet.
- **Manual Commutation** requires more time, and may not be as accurate as AutoCommutation. You will have to perform this method if:
 - Your motor is mechanically restrained such that it is not free to move 2 revolutions + 1 electrical cycle in both directions (3 electrical cycles for a Brushless linear motor).
 - Your motor or load has a significant amount of inertia.

AutoCommutation™ Detection

The AutoCommutation routine detects the motor feedback type and polarity, and then configures the drive commutation parameters appropriately.

Brushless and linear motors with insufficient travel distance (two revolutions plus one electrical cycle for rotary motors, or three electrical cycles for linear motors) or large amounts of inertia will require the Manual Commutation Procedure instead. AutoCommutation detection is not required for brush-type motors.

Before you run AutoCommutation, be sure you:

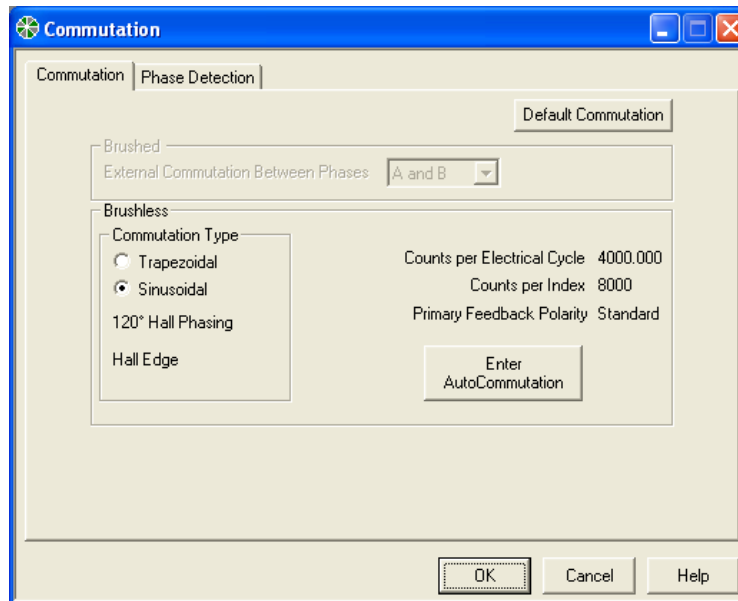
- Enter in the correct motor information in the motor data page.
- Specify the correct feedback information.
- Specify limits to protect the motor.
- Tune the current loop.
- De-couple the motor from any load and secure the motor. Sudden motion will occur!

If you have not done the preceding, see the corresponding sections in this manual.



For brushless and linear motors with sufficient travel distance, proceed as follows:

1. Click the Commutation Block in the main block diagram.
2. Select the *Commutation* tab.



3. Ensure *Sinusoidal Commutation* is selected.
4. Verify that indicated *Counts per Electrical Cycle* and *Counts per Index* values are correct. (The primary Feedback Polarity will be determined during Auto Commutation).
5. If drive is disabled, click the Stoplight icon  to enable the drive.
6. Click *Enter AutoCommutation* to open the Commutation Data window.

7. Ensure the *Reacquire Commutation* checkbox is checked. This ensures that the commutation settings will be adjusted if there is a synchronization error.
8. Click *Start AutoCommutation* to begin the process. During the Auto Commutation process, monitor the distance traveled in each direction. Rotary motors will turn two revolutions plus one electrical cycle in each direction. Linear motors will move three electrical cycles in each direction.
9. When AutoCommutation is complete, select whether the motor has moved the proper distance ("Yes") or has not moved the proper distance ("Edit Motor Data"). If the motor did not move the proper distance, verify the pole count or pole pitch in the motor data window. Click OK in Motor Data to return to the AutoCommutation window.
10. Select the appropriate mode of commutation synchronization.
 - For motors with hall sensors and encoder feedback, select *Sinusoidal With Synchronization*. Synchronize on the encoder index if available. Synchronizing on the *Hall Edge* prohibits use of the index for homing.
 - For motors using encoder with index channel only or resolver, select *Sinusoidal with Synchronization* and select *Encoder Index* for the synchronization signal.

If you have a resolver, then synchronization is not an option.

11. Click OK.

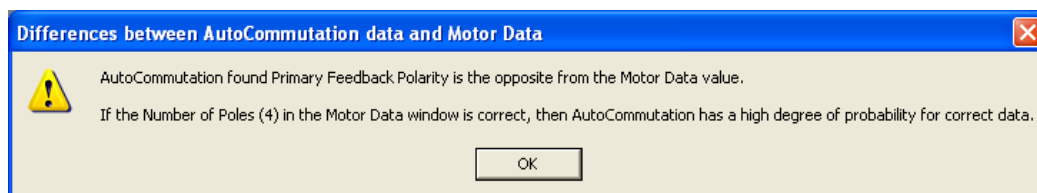
12. In some cases, the AutoCommutation results will differ (slightly) from the values entered in the Motor Data window (e.g., Counts/Electrical Cycle, Counts/Index). In those cases, you may choose between using the value determined by Autocommutation or the value from the Motor Data window. Typically, it is recommended to use the value from motor data.
13. Click Accept to apply the AutoCommutation parameters.
14. Store parameters to the drive's nonvolatile memory. For review, see ["Storing the Changes onto the Drive" on page 14.](#)



Note

For brushless motors with encoder only feedback, the Phase Detection function must be utilized whenever power to the drive is cycled or a loss of sinusoidal commutation occurs. See ["Phase Detect" on page 89.](#)

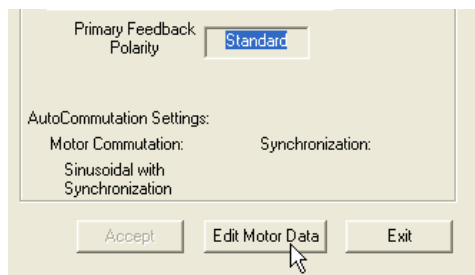
AutoCommutation Warnings After running AutoCommutation, it is possible that a warning (or warnings) may appear due to wiring errors or discrepancies between the information on the Motor Data page and the results of AutoCommutation.



AutoCommutation Warning Example, Primary Feedback Polarity

Follow these steps to successfully complete AutoCommutation:

1. Review the information in the AutoCommutation warning box, then select **OK**.
2. Select 'Edit Motor Data' from the options in the lower right hand corner.



3. Click 'OK' in the Pre-Loaded data dialog box.

4. On the Motor Data page, the relevant information will have been changed to correspond with the AutoCommutation results. Click 'OK', then click 'OK' in any dialog boxes to return to the AutoCommutation window.
5. Select 'Accept' in the AutoCommutation window. If the 'Accept' button is still greyed out, consult the general guidelines in the following table to diagnose and correct any AutoCommutation warnings, then re-run AutoCommutation.

AutoCommutation Warning Text	Warning Description
Primary Feedback Polarity Opposite from Motor Data	AutoCommutation detected that the feedback polarity of the primary encoder is the opposite of what is specified on the Motor Data page. This does not necessarily indicate an error, only that the observed polarity is different. In this case, it is best to trust AutoCommutation.
Different Feedback Devices from Motor Data	AutoCommutation detected a feedback device (usually Hall Sensors) that was not specified on the Motor Data page. Check motor data to be sure accurate information was entered.
Other Hall Phasing	AutoCommutation found Hall Sensor spacing that is outside the normal range for 60 degree or 120 degree Hall spacing. This does not necessarily indicate an error. It is acceptable to run with other Hall spacing.
Invalid Hall Sensors	AutoCommutation detected inconsistent Hall Sensors. Usually means one or more Hall Sensors are shorted. Check Hall wiring between motor and drive.
Inconsistent Index Transitions	AutoCommutation did not find the index signal consistently during its travel. Check to make sure the index signal of the encoder is properly wired to the drive. Can also indicate a noise issue. Check to make sure that the motor cables are properly shielded.
Inconsistent Encoder Transitions	AutoCommutation did not find encoder transitions during its travel. Check to make sure that the encoder's A and B channels are properly wired to the drive, and that the encoder is properly powered. Can also indicate a noise issue. Check to make sure cables are properly shielded.

Manual Commutation Procedure

The large majority of applications do not require this method for configuring a drive to commute the motor. A much easier method is provided in the setup software called AutoCommutation™ Detection. The procedure for manual commutation requires more time and may not be as accurate as the AutoCommutation method.

Because some applications cannot use the AutoCommutation method, each drive defaults to a standard switching sequence that will commute one of the six motor phase wiring combinations for a given feedback wiring configuration. Follow the steps below to find the correct motor phase wiring to commute your motor.

Before you perform manual commutation, be sure you have:

- Entered in the correct motor information in the motor data page.
- Specified the correct feedback information.
- Specified limits to protect the motor.
- Tuned the current loop.
- De-coupled the motor from any load and secure the motor. Sudden motion will occur!

Setting over speed limits

1. Go to Limits & Options--> Velocity Limits tab, set the maximum speed you wish the motor to spin for this test. Set this fairly high but not so fast it is dangerous if the motor spins away.
2. Go to Event Manager --> Advanced --> System Protection, set the Motor Over Speed event action to Disable Power Bridge and Unlimited Recoveries.



If your drive does not use a separate logic supply, store your project file to your computer disk and in the drive's nonvolatile memory.

If you need review, see ["Saving Your Setup" on page 14.](#)

Performing manual commutation

1. Ensure Trapezoidal Commutation is selected in the Current Loop > Commutation tab.
2. Verify that indicated Counts per Electrical Cycle and Counts per Index values are correct. Ignore the primary feedback polarity.
3. Make sure the feedback device is wired correctly and connected to the drive as per the drives data sheet.
4. Create a table like this one on a piece of paper (use your motor's wire labels):

Combination Number	Motor Phase Labels			Results
1				
2				
3				
4				
5				
6				

5. If the drive is enabled, click the Stoplight icon  to issue a Commanded Inhibit and disable the drive.
6. Check the Drive Status window for any faults or user inhibits, and take corrective action to clear them. The Commanded Inhibit should remain applied. Some faults in the Drive Status block are harmless and do not disable the drive, ignore these.
7. In the drive setup software, open the Waveform Generator and set up a DC waveform into the current loop with an offset of 10% of the rated continuous motor current. Ensure that Commanded Inhibit is still applied at this point.



Notice

Remove high voltage power from the drive (especially if it uses alternating current) before changing the motor phase wiring combinations.



Warning

Always be ready to disable the drive in case of a spin away or other aberrant situation.

Use the Hotkey—see ["Stoplight behavior and Hotkey" on page 9](#)—to disable the drive. This action stops motion.

Wire the motor phases according to each combination and perform the following procedure:

1. Use the  icon to enable the drive.
2. If the motor attempts to spin away, disable the drive, change the polarity of current in the waveform generator and enable again to see if the drive spins away in the opposite direction. The motor should demonstrate smooth torque of the same magnitude in both directions. If torque is smooth for both directions, mark a "good" in the results column and try the next combination.
3. If the motor does not spin, carefully nudge it to see if it will begin spinning. In this case either the current is too low or the commutation angle is incorrect. Try increasing the current magnitude in small increments until either the motor spins or you reach 25% of continuous current. If the motor does not spin with increased current, or spins only after help is applied, mark a "bad" in the results column. Reset the current to 10% and try the next combination.
4. If the motor spins faster in one direction than the other, mark a bad in the results column and try the next combination
5. If none of the combinations yields a good result, contact the drive manufacturer.
6. When finished, click Not Connected on the Waveform Generator to remove the command signal from the drive.

You should only find one combination that smoothly turns the motor in both directions with strong torque; use this wiring combination.

- If using *Trapezoidal Commutation*, this procedure is finished.
- If using *Sinusoidal Commutation*:
 - In the Commutation tab select Sinusoidal as the Commutation Type and then close the Current Loop window.
 - Open the Waveform Generator and setup a DC waveform into the current loop as before (offset of 10% of the rated continuous motor current).
 - Enable the drive, however, be prepared to disable the drive in case of spin away or any other dangerous situation.
 - If the motor spins smoothly, no further changes are necessary. If it does not, close the Waveform Generator and open the Motor Data > Primary Feedback tab. Change the Primary Feedback Polarity to which ever option is not currently selected. Accept changes and, if desired, verify that the motor now spins smoothly to the small current command given previously.
- Double-check the feedback polarity.

Go back to --> Velocity Limits, and set the desired Motor Over Speed. Go back to Event Manager --> Advanced --> System Protection and configure the Motor Over Speed event action for your application. Store parameters to the drive's nonvolatile memory. For review, see ["Storing the Changes onto the Drive" on page 14](#).

The drive is now ready either for tuning the outer loops, or final commissioning and use.

Phase Detect

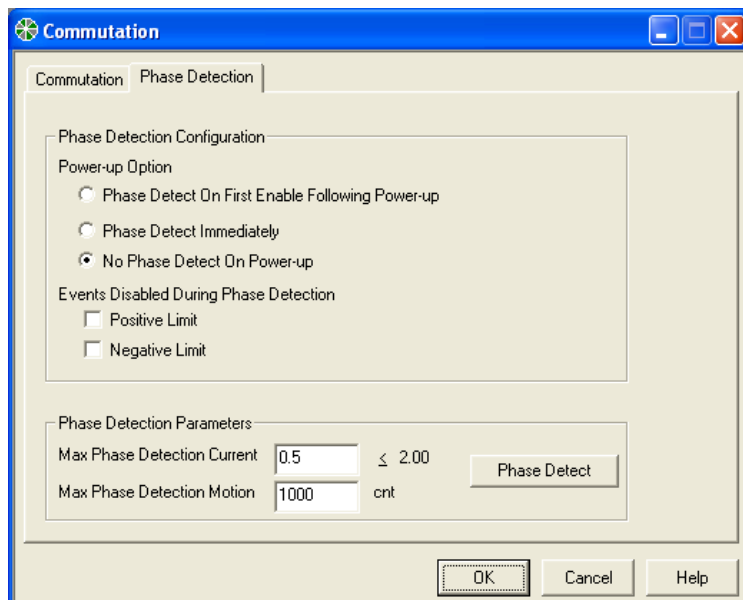
Phase detect is required for use with brushless motors with encoder feedback and without hall sensors. This routine must be performed:

- Before the motor can properly be commutated each time the drive power is cycled.
- Anytime sinusoidal commutation is lost.

The reason is that without hall sensors, the motor position is initially unknown, and therefore cannot be properly commutated until a positioning routine is followed. Phase detect requires the motor to vibrate for a few seconds, and can be set up to be performed via a digital input, or automatically on power-up.

Couple the motor to the load before you perform phase detection.

Phase detect is also used with absolute feedback devices (i.e., resolver or absolute encoder). This form of phase detect is automatically performed, instant on power-up, and does not require motor motion.



Notice

Be sure to enter motor data and run automatic or manual commutation for the first time before running phase detect.

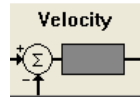
- **Power-up Option:** Under most circumstances, the appropriate setting is Phase Detect On First Enable Following Power-up. However, other options may be used depending on the configuration of your drive and motor.
- **Events Disabled During Phase Detection:** The positive and/or negative limit switches may be disabled during phase detect to avoid premature phase detect failure.
- **Max Phase Detection Current:** This is the current used during phase detection. It should be large enough to move the motor (and load) smoothly, but not so much that the motor overshoots. A good starting current is one quarter of the RMS current to be used in your application.
- **Max Phase Detection Motion:** Enter a value greater than the required motion. If the actual phase detection exceeds this value, a fault will occur. The required motion is typically 5%-15% of one revolution.
 - It may be necessary to vary the Phase Detection Current and Motion to ensure successful phase detection.
 - You may wish to monitor the following status events: Phase Detection, Phase Detection Complete and Phase Detection Fault. These can be monitored with the Drive Status window or can be assigned to digital outputs and monitored with a controller.
 - If you are trying to perform phase detection with no load on the motor, very little current will be required.

To perform Phase Detection from within the Commutation window, use the following procedure:

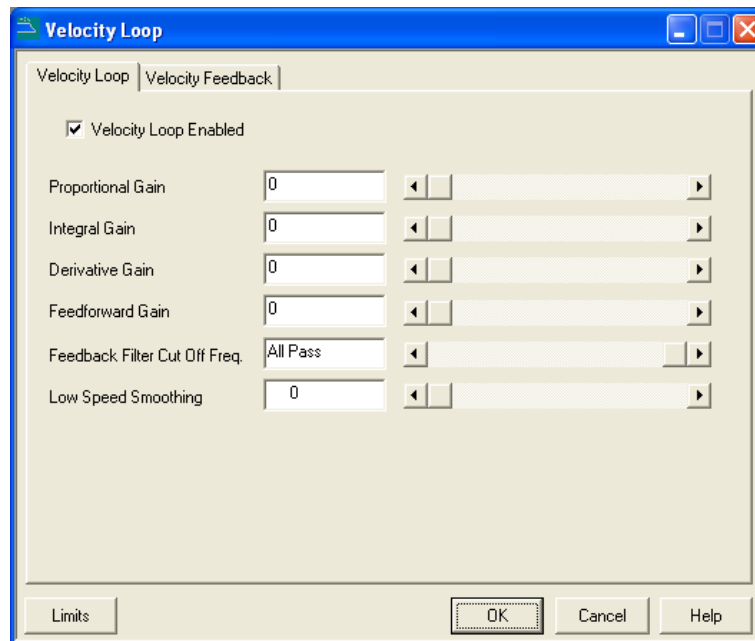
1. Enter the appropriate current and motion values in the phase detection fields.
2. Click the Phase Detect Button. Motor will begin to move back and forth.
3. After motor movement stops, click the End Phase Detect button.
4. Check Drive Status to make sure the phase detect routine was successful.

Velocity Loop Tuning

Velocity loop tuning is dependant on the mechanical load, and therefore will change with any mechanical system changes. Velocity loop tuning should be performed with the motor installed in the system and connected to the load.



Open the Velocity Loop window by clicking on the velocity loop icon in the main block diagram. It provides access to the velocity control parameters and velocity feedback settings.



Proportional Gain	Increase for faster response. Excessive proportional gain can cause overshoot and oscillation.
Integral Gain	Increase to eliminate steady-state error and increase stiffness (i.e., amount torque/force per deflection). Excessive integral gain can cause instability and jitter.
Derivative Gain	Increasing to dampen response and reduce overshoot. Excessive derivative gain results in a more sluggish response. Also, depending on the velocity feedback source, it may cause excessive jitter and noise.
Feed-forward Gain	Creates a direct current demand, based on the velocity demand. This gain does not affect closed loop behavior, but can help improve velocity-tracking capability.
Feedback Filter Cut-off Frequency	This low-pass filter reduces velocity ripple (due to digitization). However, this will also affect closed loop performance. A typical setting is between 50Hz and 1500Hz. For more information, see Feedback Filter.
Low Speed Gain	Stabilizes the velocity loop during low-speed movement. To tune the low speed gain, use the waveform generator to command a slow speed (1 or 2 rpm) and look at the velocity measured with the oscilloscope. Adjust the Low speed gain to minimize the velocity spike as seen by the scope. Alternatively, this gain can be used to reduce jitter when position is tuned around the velocity loop.

The Limits button opens the Limits and Options --> Velocity Limits window.

The Velocity Feedback tab shows the Velocity Feedback window.

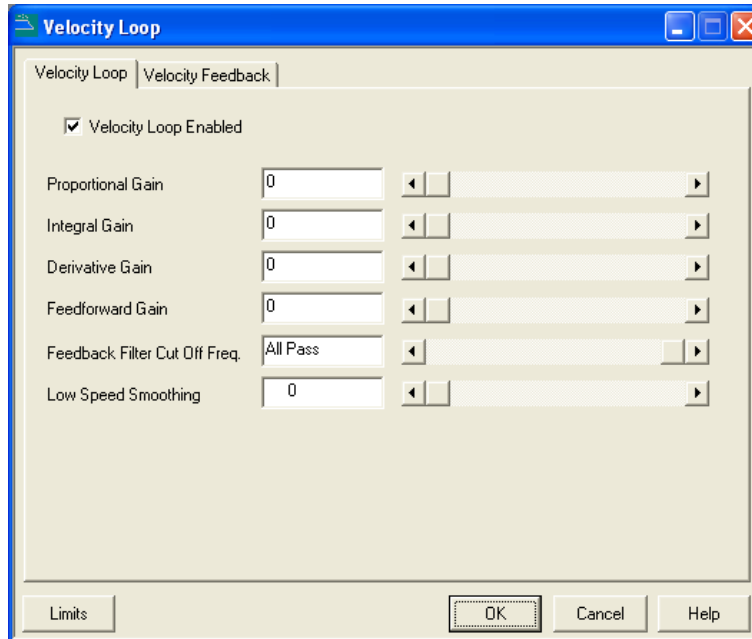
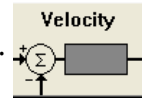


Make sure that the load is free to move and coupled to the motor. Sudden motion may occur!

Tuning of the velocity loop should only be performed after current loop tuning and motor commutation.

Step 1: Velocity Loop window setup

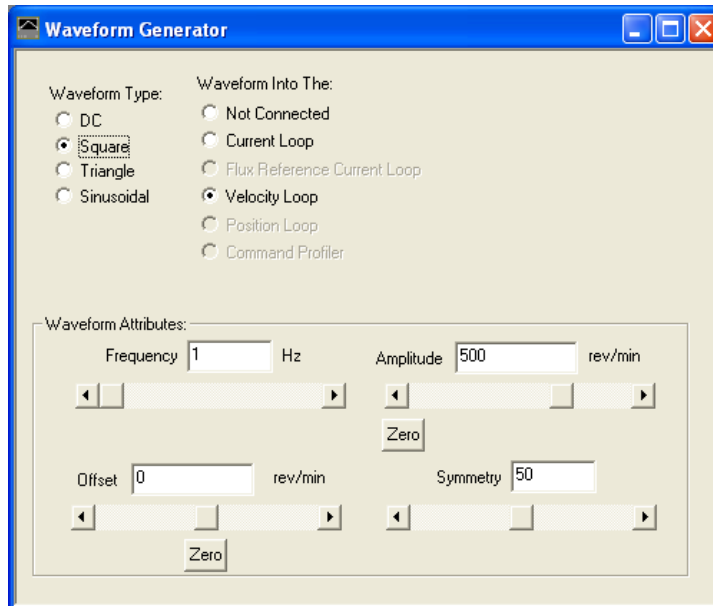
1. Verify the drive is disabled .
2. From the Main Block Diagram, open the Velocity Loop window.



3. Check the "velocity loop enabled" checkbox.
4. Set the Proportional, Integral, Derivative, Feedforward, and Low Speed gains to zero. Set the Feedback Filter Cut Off Freq. all the way to the right until it says All Pass.

Step 2: Waveform Generator setup To open the Waveform Generator window, do one of the following:

- Select Tools > Waveform Generator on the main menu bar.
- Click the Waveform Generator icon  on the tool bar.

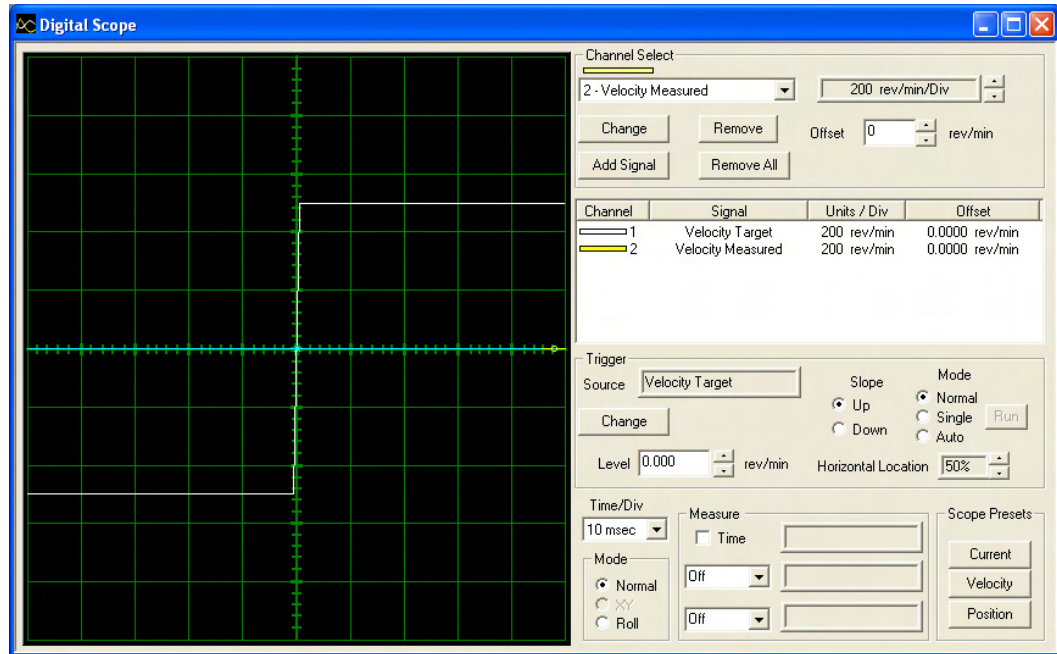


Set up the Waveform Generator as follows.

1. Select the *Square* Waveform Type.
2. Set *Frequency* to around 1-3 Hz. The Frequency should be slow enough to achieve commanded velocity, but fast enough to prevent the system from reaching a mechanical limit.
3. Ensure *Offset* is zero.
4. Ensure *Symmetry* is 50%.
5. Select *Waveform Into The Velocity Loop*.
6. Set the waveform amplitude to approximately 10% of motor nominal speed.

Step 3: Oscilloscope setup To open the Oscilloscope window, do one of the following:

- Select Tools > Oscilloscope on the main menu bar.
- Click the Oscilloscope icon  on the tool bar.

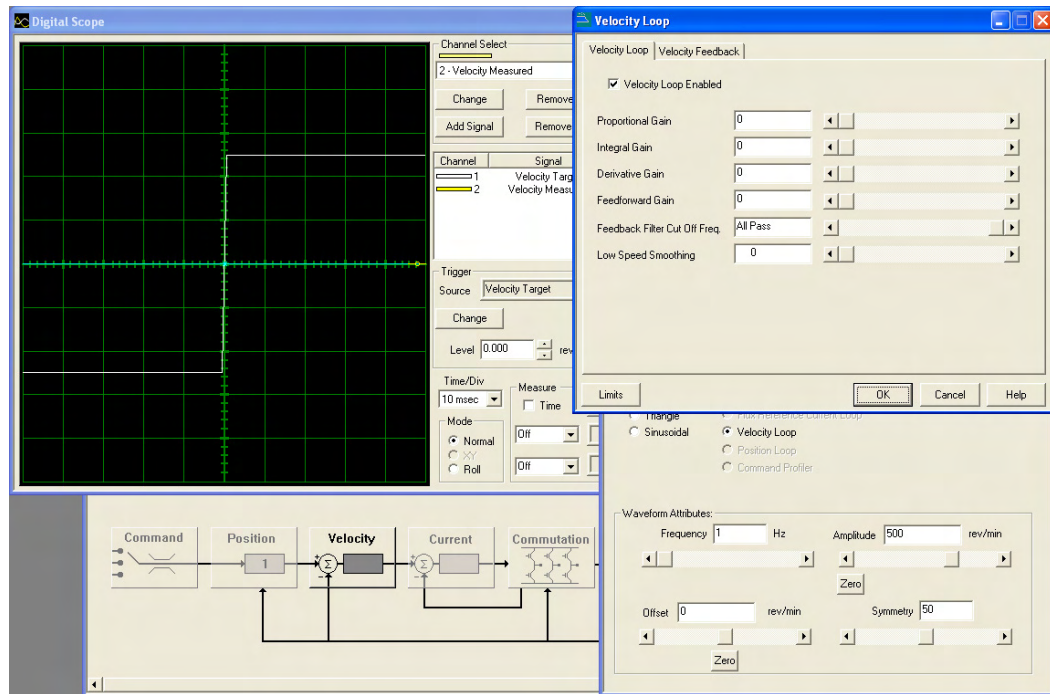


To configure the oscilloscope for velocity loop tuning, select the "Velocity" option from the Scope Presets section of the Digital Scope window.

The oscilloscope can also be configured for velocity loop tuning manually by following these steps:

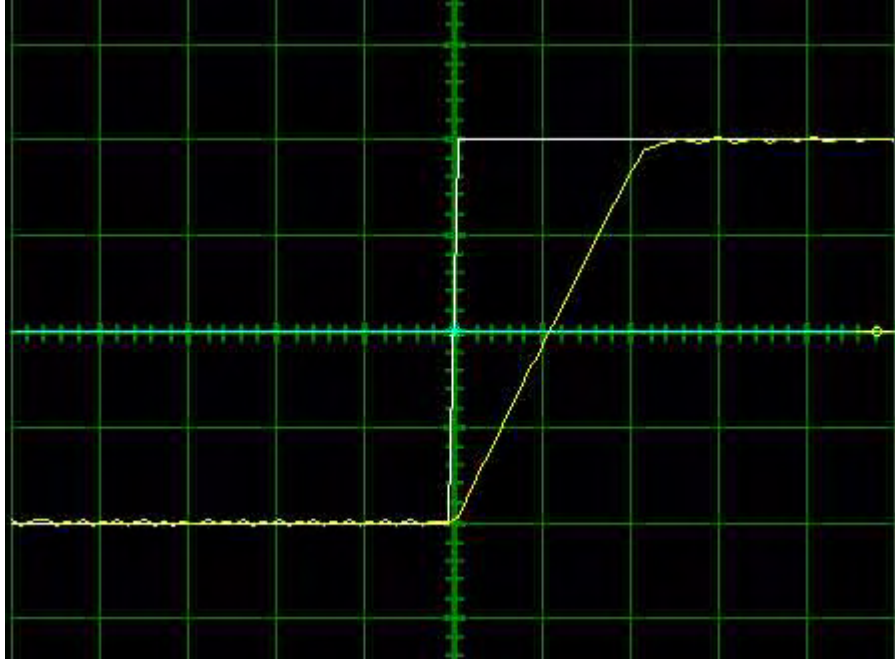
1. Use the drop down menu to change the channel 1 signal to **Velocity Target**.
2. Use the drop down menu to change the channel 2 signal to **Velocity Measured**.
3. Change the Trigger Source to Velocity Target with the Level set to zero.
4. Ensure Trigger Mode is Normal.
5. Change Time/Div to 10-20msec.

Step 4: Tuning Position the Scope, Waveform Generator, and Velocity Loop windows such that a majority of all the windows are visible. The best method is to place the oscilloscope in the lower left corner, while placing the velocity loop and Waveform Generator windows in the upper and lower right corners as shown below.

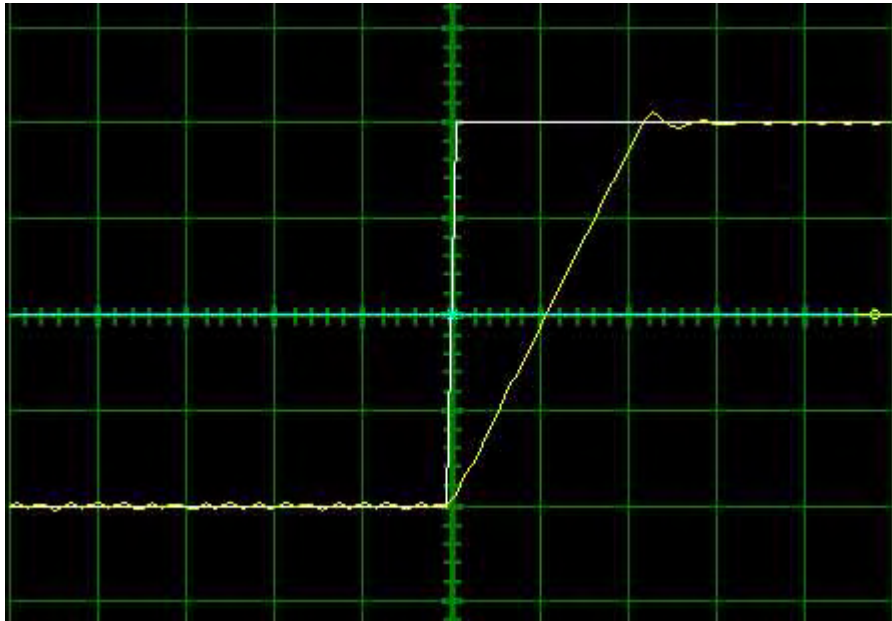


1. Enable the drive by clicking the Stoplight icon  .
2. The feedback filter cutoff frequency is used to dampen oscillations and noise in the velocity measurements. During the next steps, if the motor exhibits excess noise, bring the feedback cutoff frequency down to about 1000Hz or less. It is usually ok to start with this value also.

3. Proper Velocity loop tuning starts with zero integral gain while increasing the proportional gain until a "knee" is formed (with no overshoot) in the Velocity Measured trace as shown below. There may or may not be an error between the Target and Measured traces, the key is to have a smooth knee shape.



4. At this point the Proportional gain is left alone and the Integral gain is increased slowly until the "knee" begins to deform as shown below. It is OK if the waveform does not start to distort until the integral gain is very high. When the distortion occurs, back off the Integral gain until the knee becomes smooth again.



5. Next, in order to improve the smoothness of the response, it may be beneficial to adjust the feedback filter cutoff frequency. For most systems, the ideal cutoff frequency will be somewhere between 50Hz and 1500Hz.
6. Most systems will be tuned properly at this point. If your system requires fine-tuning, you may adjust the derivative and feed-forward gains.
7. When tuning is complete, select the 'Not Connected' option in the waveform generator. If the motor starts to make audible noise, increase the Low Speed Gain until the vibration and noise stops.
8. Disable the drive by clicking the Enable/Disable Drive icon .
9. Store parameters to the drive's nonvolatile memory. If you need a review, see ["Storing the Changes onto the Drive" on page 14](#)
10. Click "OK" in the Velocity Loop window to save and close your gain settings.



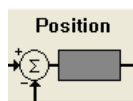
Reminders

Do not close out of the Velocity Loop window by selecting the "X" in the upper right corner. Closing out this way will not save your gain settings. You must close out of the Velocity Loop window by clicking "OK".

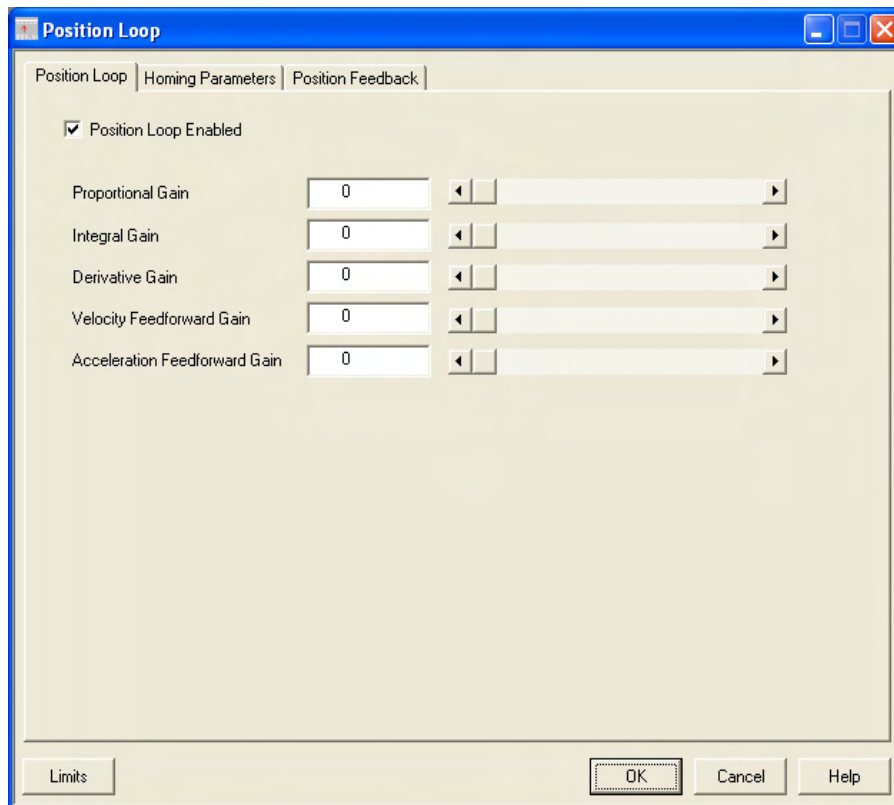
Position Loop Tuning

Position loop tuning is dependant on the mechanical load, and therefore will change with any mechanical system changes. Position loop tuning should be performed with the motor installed in the system. The position loop can be closed around velocity or torque mode (depending on whether the velocity is enabled or disabled). If it is closed around velocity mode, the position loop algorithm output becomes the new velocity set point. If it is closed around torque mode, the position loop algorithm output becomes the new torque set point. There are some important differences in the tuning process and application of these two approaches:

- **Position around Velocity:** This mode is most common in "contouring" application, where a position trajectory must be tracked very closely. The velocity loop provides additional "stiffness", and keeps the dynamic position errors minimal, since the system now reacts to not just position errors, but also velocity errors (which can be interpreted as position error changes). It is important to start with a stable yet responsive velocity loop. Typically, it is sufficient to just use the position loop proportional gain. Feedforward gain can be added to improve tracking performance (i.e. minimize the difference between commanded and actual position). It is best to use a small step command as a reference signal during tuning.
- **Position around Torque:** This mode is most common in point-to-point applications, where actual motion between start and end point is not very critical. In this case, velocity loop tuning can be avoided. This can be advantageous if the velocity feedback is poor (e.g., low resolution encoder, poor encoder quadrature...). In this case, the tuning process requires that the position loop proportional and derivative gain are increased simultaneously, unless the system has sufficient friction, in which case no derivative gain is necessary. Once a stable response is achieved, integral gain can be added to improve stiffness. It is best to use a triangular waveform or a step command with the profiler enabled as a reference signal during tuning.



Open the Position Loop by clicking on the position loop icon in the main block diagram. It provides access to the position control parameters.



Proportional Gain	Increasing this gain results in faster response. Excessive proportional gain can cause overshoot and oscillation.
Integral Gain	Increasing this gain will eliminate steady-state error and increase stiffness (i.e. amount torque/force per deflection). Excessive integral gain can cause instability and jitter.
Derivative Gain	Increasing the derivative gain results in a more damped response and is typically used to reduce overshoot. Excessive derivative gain results in a more sluggish response. Also, depending on the position feedback source, it may cause excessive jitter and noise.
Feed-forward Gain	Creates a direct current demand, based on the velocity demand. This gain does not affect closed loop behavior, but can help improve position-tracking capability.
Acceleration Feed-forward Gain	Creates a direct current demand, based on the acceleration demand. This gain does not affect closed loop behavior, but can help improve position-tracking capability.

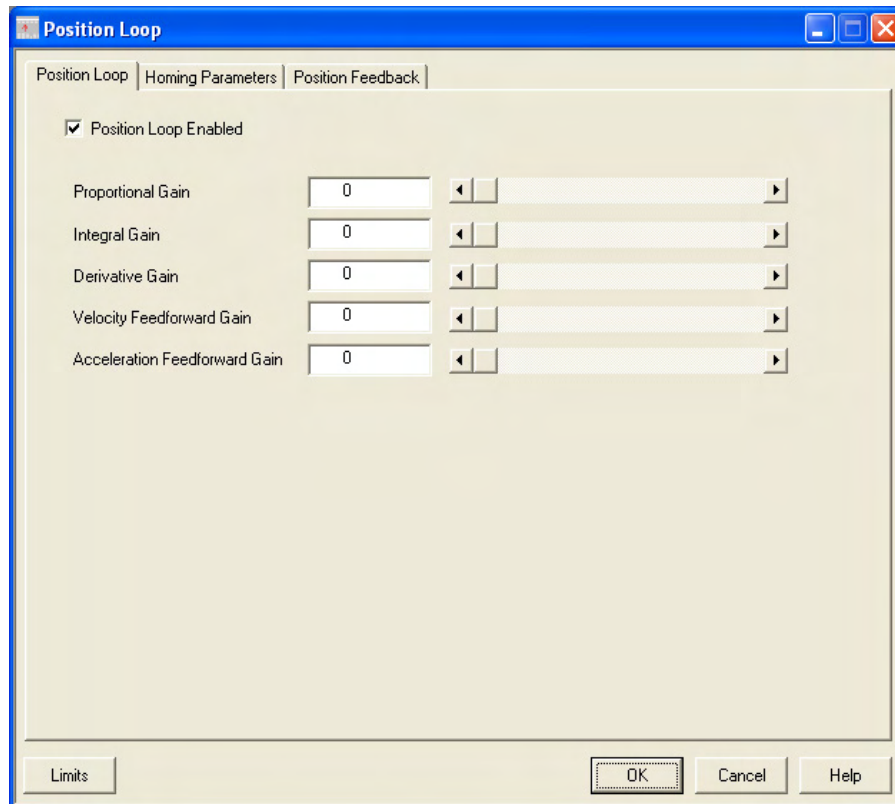
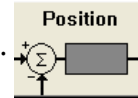
The Limits button opens the Limits & Options > Position Limits window.

The Homing Parameters tab shows the Homing window.

The Position Feedback tab shows the Position Feedback window

Step 1: Position Loop window setup

1. Verify the drive is disabled .
2. From the Main Block Diagram, open the *Position Loop* window.

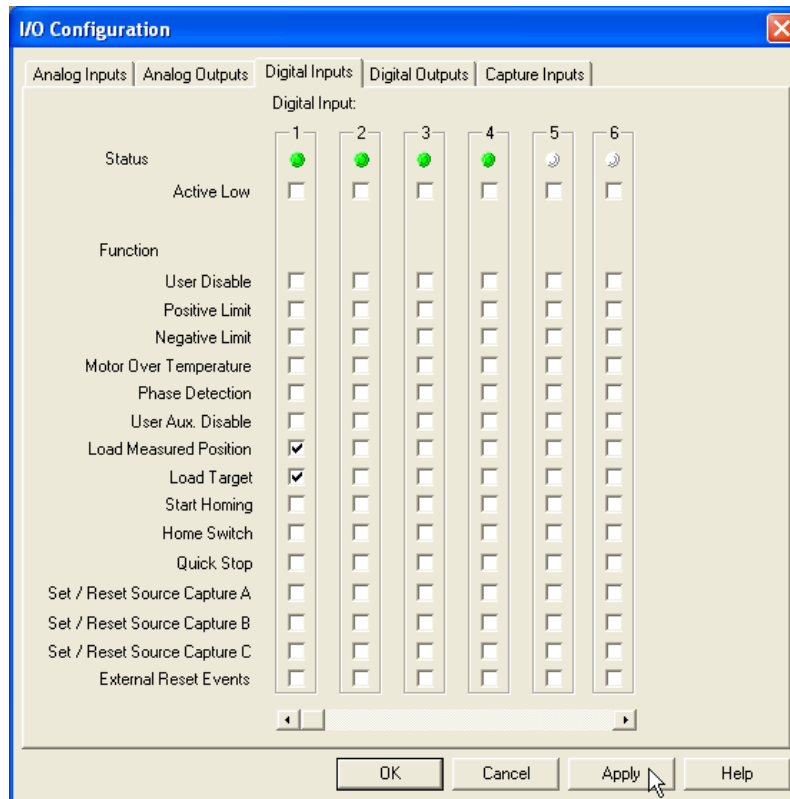


3. Select the check box for *Position Loop Enabled*.
4. Set the *Proportional*, *Integral*, *Derivative*, *Velocity Feedforward*, and *Acceleration Feedforward* gains to zero.

Step 2: Zero the measured and target position

It may be necessary to zero the target and measured position so that they are equal to each other, and the motor does not run away when the bridge is enabled. Before continuing with this step, click on the Limits & Options block in the Main Block Diagram and select the position limits tab. Verify the value of Measured Position is set to zero.

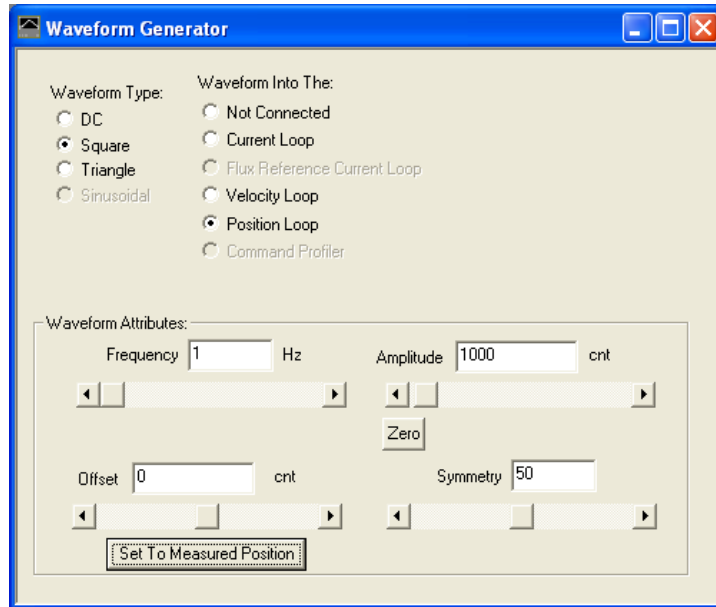
1. From the Main Block Diagram, click *Inputs/Outputs* button.



2. Select the Digital Inputs tab
3. Set the Measured Position to zero by checking *Load Measured Position* under an assigned input. Set the Target Position to zero by checking *Load Target* under an assigned input. Click the apply button.
4. Clear the boxes checked in the above step, and once again click Apply.
5. Click OK to close the *I/O Configuration* window.

Step 3: Waveform Generator setup To open the Waveform Generator window, do one of the following:

- Select Tools > Waveform Generator on the main menu bar.
- Click the Waveform Generator icon  on the tool bar.

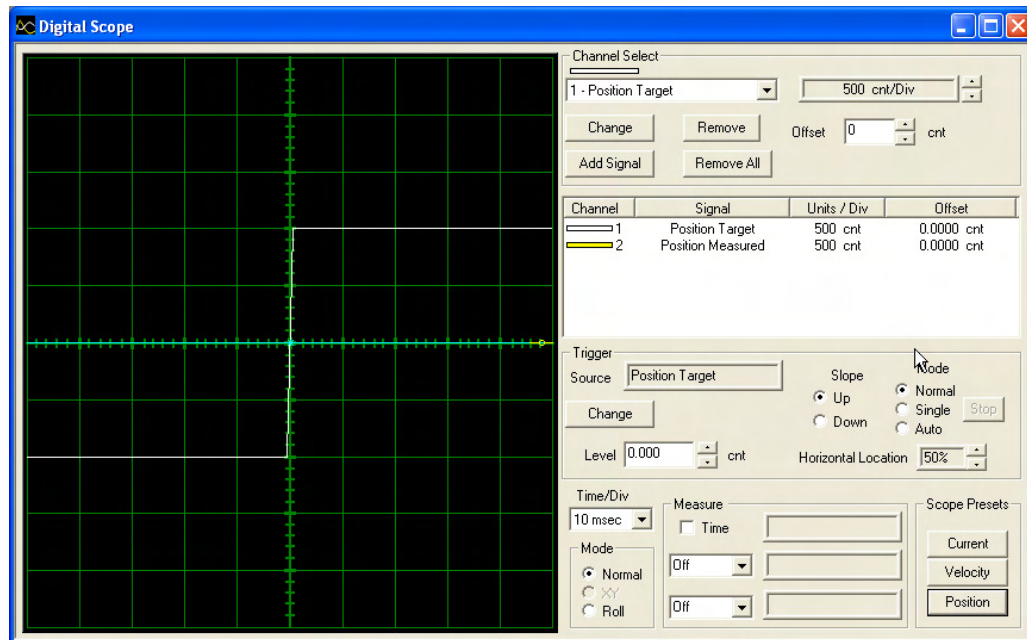


Set up the Waveform Generator as follows.

1. Select the *Square* Waveform Type.
2. Set *Frequency* to around 1-3 Hz. The Frequency should be slow enough to allow the motor to settle in position.
3. Ensure *Offset* is zero.
4. Ensure *Symmetry* is 50%.
5. Select *Waveform Into The Position Loop*.
6. Set the waveform amplitude between 1/8 and 1/2 revolution for a rotary motor.

Step 4: Oscilloscope setup To open the Oscilloscope window, do one of the following:

- Select Tools > Oscilloscope on the main menu bar.
- Click the Oscilloscope icon  on the tool bar.

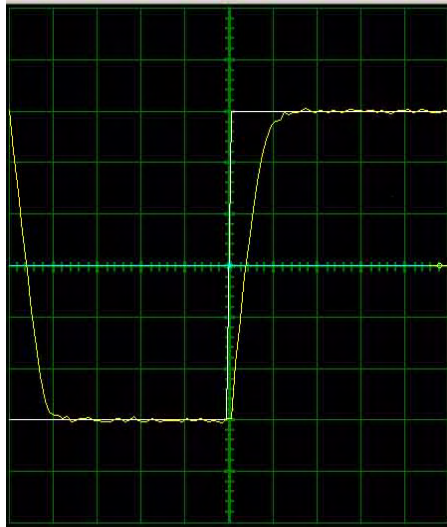


To configure the oscilloscope for position loop tuning, select the "Position" option from the Scope Presets section of the Digital Scope window.

The oscilloscope can also be configured for position loop tuning manually by following these steps:

1. Use the drop down menu to change the channel 1 signal to **Position Target**.
2. Use the drop down menu to change the channel 2 signal to **Position Measured**.
3. Change the Trigger Source to Position Target with the Level set to zero.
4. Ensure Trigger Mode is Normal.
5. Change Time/Div to 20-50 msec.

Step 5: Tuning



1. Position the Scope, Waveform Generator, and Current Loop windows such that a majority of all the windows is visible.
2. Enable the drive by clicking the Enable/Disable Drive icon .
3. Use the Proportional Gain, Integral Gain, and Derivative Gain sliders or arrow buttons to adjust the Motor Position Measured waveform on the oscilloscope and match the Motor Position Target as closely as possible without excessive overshoot. It is not necessary to adjust the Velocity or Acceleration Feed-forward Gains.
4. Readjust the Gains as Necessary.
5. Disable the drive by clicking the Enable/Disable Drive icon .
6. When position loop gain adjustments are complete, click Not Connected on the Waveform Generator to remove the command signal from the drive.
7. Store parameters to the drive's nonvolatile memory. For review, see ["Storing the Changes onto the Drive" on page 14](#).
8. Click "OK" in the Position Loop window to save and close your gain settings.



Reminders

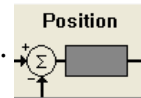
Do not close out of the Position Loop window by selecting the "X" in the upper right corner. Closing out this way will not save your gain settings. You must close out of the Position Loop window by clicking "OK".

Homing Parameters Tab

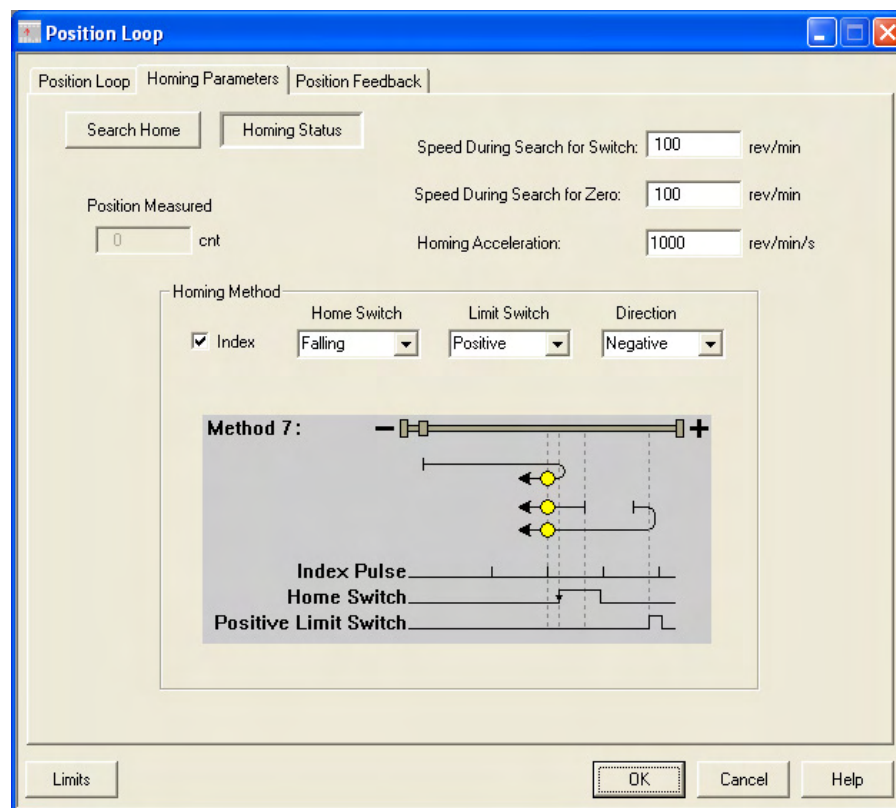
Many different homing routines are supported. These routines rely on signals such as limit switches, home switches, and encoder indexes to accurately position the load.

To view the appropriate homing routines:

1. From the Main Block Diagram, open the *Position Loop* window.
2. Click on the Homing Parameters tab.
3. Select the drop-down menus.



If no switches, index, or direction is selected, the homing routine will default to "Current Position". The "Current Position" homing routine will set the measured position to zero when executed. The drive must be enabled for this to work.



The previous example uses the index, the falling home switch edge and the positive limit switch to define the homing routine. The direction in which homing ends is in the negative direction as shown by the arrow. For this particular routine, there are three possible scenarios.

The scenarios are described as shown from top to bottom.

- The home switch is inactive. Motion begins in the positive direction. When the home switch is encountered, motion starts in the negative direction. Homing completes at the first index pulse after the falling edge of the home switch.
- The home switch is active. Motion begins in the negative direction. Homing completes at the first index after the falling edge of the home switch.
- The home switch is inactive. Motion begins in the positive direction. When the positive limit switch is encountered, motion starts in the negative direction. Homing completes at the first index after the falling edge of the home switch.

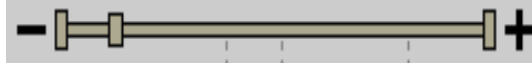
Homing Status: This shows the status of the homing routine. It may display "Homing Active" or "Homing Complete".

Homing Speeds: There are two homing speeds to take into consideration; the speed during the search for the first switch, and the speed during the search for zero/home. Typically, the speed during the search for the switch is set to be faster while the search during the search for home or zero is slower. The slower the speed, the more accurate the homing routine should be.

Homing Acceleration: A single value is used to define the acceleration and deceleration of all moves during the homing routine. Setting the acceleration allows the motor to come to a stop within a realistic predefined time (not instantaneous), increasing the repeatability of the homing routine.

Homing method The set of drawings below illustrate the different components used to define the different homing routines. The components are grouped in the diagram to show events relative to motor/load position.

Load and physical limits: The square near the middle of the drawing shows the load object that is to be moved. The end points represent physical limitations or barriers in which the load cannot travel past. The left side is in the negative direction with the right side in the positive direction.



Direction of travel: The vertical line on the right side represents the starting position. The load travels in the direction of the arrow. In the drawing shown, the load would begin traveling in the negative direction and then switch directions to move in the positive direction. The circle represents the final resting position.



Index Pulse: Each vertical line represents one index pulse.



Limit and Home Switches: As shown, the switch can be either high or low. The vertical lines represent a toggle point.



5 Downloading the Firmware

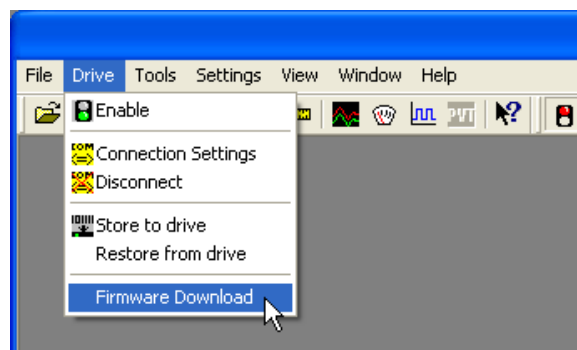
Each time the manufacturer releases a new setup software version or issues a firmware patch, you should update the firmware on your existing digital drives. When you work closely with the manufacturer, particularly for custom products, firmware changes may be required several times throughout your development process.

Prepare for Download

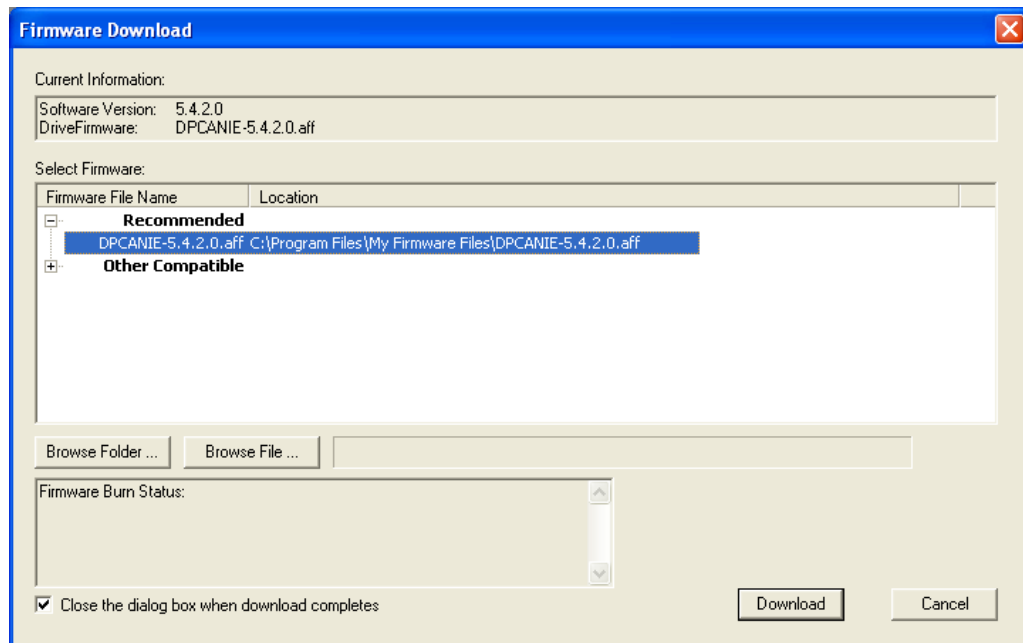
1. Connect to the drive.
2. Set the Drive > Connection Settings to a high baud rate.
3. Make sure the parameters are correct in both the setup software and the drive.
4. Store parameters to the drive's nonvolatile memory.

Open the Firmware Download Window

Select Drive > Firmware Download on the menu bar.



This action opens the Firmware Download window.



This window allows change to the drive run-time firmware. For example, you may need to upgrade when a new version of software is to be used with an older drive or when a new drive needs a previous version to work in a system.

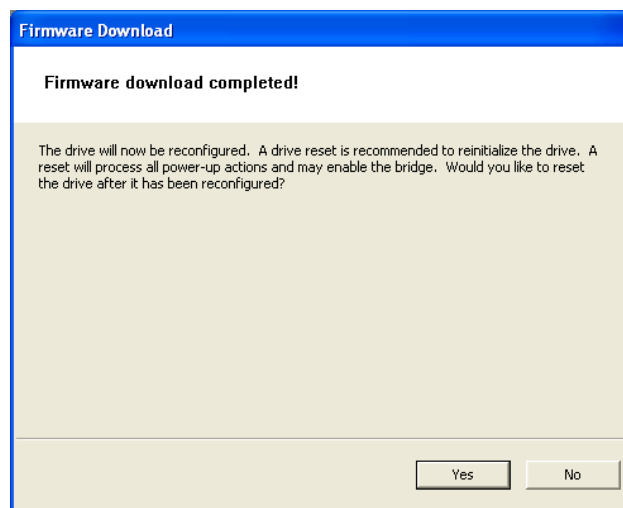
Check the Current Information window to view which firmware is currently in the drive. If the firmware file name matches the recommended name in the Select Firmware window, a firmware upgrade is unnecessary and you may click the cancel button. If the two names are different, you must update the firmware.

Find the appropriate firmware file name in the release notes included with your setup software.

Browse Folder/Browse File: If the drive firmware is not installed in the default directory, you may need to browse for it. Use these buttons to navigate to where the firmware file is located.

Downloading the Firmware

1. Select the recommended firmware file.
2. Click on the Download button.
This process may take several minutes depending on your connection.
3. Close the dialog box when download completes: This box is checked by default so that you will return to the block diagram after firmware upgrade completes.
4. If the 'Bridge State on Power-up' option in the Power-up Control tab in Limits and Options is set to **Enable**, you will see a dialog window during the download asking if you would like to reset the drive after the firmware download is complete:



Be aware that resetting the drive in this case will cause the power bridge to be enabled after the download is complete, unless there is a hardware limiting event active (invalid halls, digital inputs, etc). If you choose not to reset the drive, the bridge will be disabled upon download completion, and the drive will not go through its normal power-up sequence.

5. When the upgrade is complete, store the parameters to nonvolatile memory.
6. Read the release notes for information about new features and issues.



Caution

Do not power down or lose your connection during the process. If this happens, you may have to restart the download, or in extreme cases, send the drive back to the manufacturer.



A Diagnostic Functions

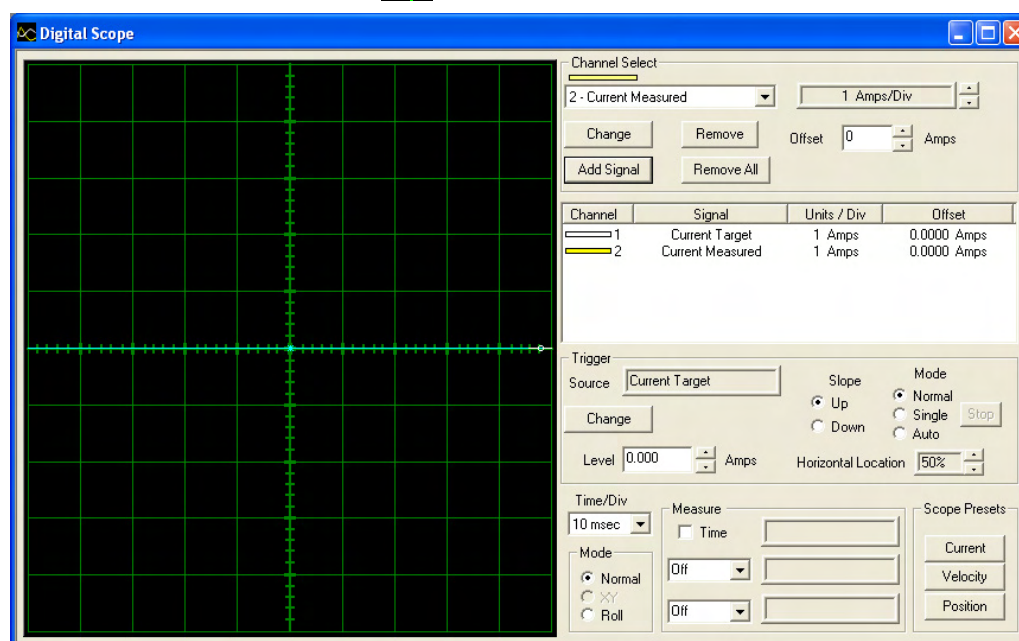
This appendix describes helpful tools provided by the setup software.

Digital Oscilloscope

The digital scope is a powerful tool used for tuning and diagnostics. You can select from more than forty different signals to monitor while testing or troubleshooting your machine. Slower baud rates can affect the scope performance.

To open the digital oscilloscope, do one of the following:

- Select Tools > Oscilloscope on the menu bar.
- Click on the oscilloscope  icon on the tool bar.



Digital Scope Window

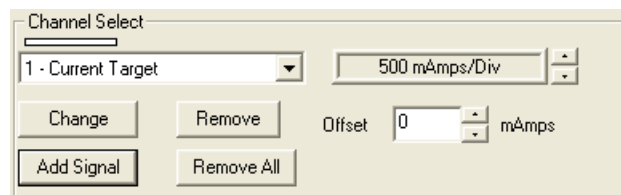
The oscilloscope provides real-time feedback during tuning and setup. This multichannel digital scope behaves similarly to a traditional oscilloscope but provides access to internal drive signals. You can show up to eight channels at any time depending on the bandwidth used for each channel. The units used in the vertical division setting depend on the selected signal.

Standard prefixes such as μ (micro-), m (milli-), k (kilo-), M (mega-), are used for larger scaling factors. The bridge does not need to be enabled to use the scope. All that is required is that the drive be powered up and connected.



Note

Even if the setup software is not connected to a drive, you can still adjust the settings.



Channel Select

- **Channel select drop down menu:** Allows you to select which channel you wish to display.
- **Change:** Changes the currently selected signal to another one of your choice.
- **Add Signal:** Adds a new channel to the scope (if available) and allows you to select a corresponding signal of your choice. This button will be disabled (grey) if all oscilloscope channels are used.
- **Remove:** Removes the selected channel from the scope.
- **Remove All:** Removes all channels, resulting in no signals displayed.
- **Signal Scaling:** Allows you to adjust the scale in units per division. The type of units used changes depending on the signal chosen. The signal to be scaled corresponds to the channel selected in the channel select drop down menu.
- **Offset:** Adjusts the offset of the signal shown in the digital scope display. The offset corresponds to the channel selected in the channel select drop down menu.

A list of available channels and their definitions can be found in the [“Signal Definitions” on page 129](#).

Channel	Signal	Units / Div	Offset
1	Current Target	1 Amps	0.0000 Amps
2	Current Measured	1 Amps	0.0000 Amps

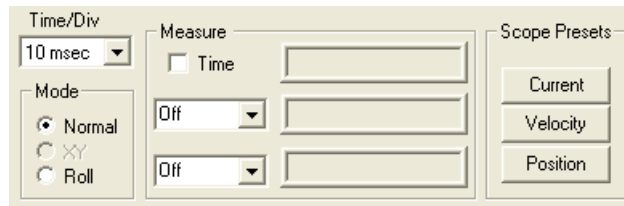
Signal Window

- **Channel:** Shows the color associated with the channel as seen in the digital scope display.
- **Signal:** Shows the signal associated with the color and channel.
- **Units/Div:** Shows the units per division for the corresponding signal as seen in the digital scope display.
- **Offset:** Shows the offset associated with the signal as seen in the digital scope display

Trigger	
Source: Current Target	Slope: ☒ Up ☐ Down
Change	Mode: ☒ Normal ☐ Single ☐ Auto
Level: 0.000 mAmps	Run
Horizontal Location: 50%	

Trigger Settings

- **Source:** Displays the currently selected signal to be used as a trigger.
- **Change:** Allows you to change the trigger source.
- **Level:** Allows you to select the level at which you want the scope to trigger.
- **Slope:** Sets the trigger slope to positive slope or negative slope.
- **Mode:** Sets the trigger mode to one of the following:
 - Normal Mode: The scope triggers according to the settings specified.
 - Single: The scope triggers once, according to the settings specified, after Run/Stop button is selected.
 - Auto: The scope triggers automatically, ignoring the settings specified.
- **Horizontal Location:** Allows you to adjust the horizontal (time-based) level at which the scope triggers.



Time and Mode Settings / Scope Presets

- **Time/Div:** Sets the horizontal scaling as seen on the scope in units of time per division
- **Mode:** Sets the mode in which the scope captures data. Normal mode refreshes the screen in intervals dependant on the time per division selected. A longer time period selected will take longer to update the scope. Roll mode captures data and refreshes the screen in a continuous roll. Note: you will be limited to 200 msec/Div minimum while in roll mode.
- **Measure:**
 - *Time:* This allows you to measure time differences between any two points on the scope display. Click the Time checkbox to display two vertical lines on the scope plot. The difference in time between the two lines is displayed in the box to the right of the check box. Left click to drag each line or right click to drag both.
 - *Signal Level:* Select a channel for measurement from one of the two dropdown boxes. You may use either of the two dropdown menus to select a channel. The vertical difference between the horizontal lines is displayed next to the channel selection dropdown; the selected channels units apply. Left click to drag each line or right click to drag both.
- **Scope Presets:** Automatically configured oscilloscope settings that are frequently used when tuning the drive. Each preset has pre-determined unit and time per division scaling. Click on the corresponding button to either load a preset or save the existing layout as a preset. The presets will be reset to the defaults when DriveWare is closed and re-opened.
 - *Current:* Configures the oscilloscope settings for monitoring a target current command and the measured drive output current.
 - *Velocity:* Configures the oscilloscope settings for monitoring a target velocity command and the measured motor velocity.
 - *Position:* Configures the oscilloscope settings for monitoring a target position command and the measured motor position.

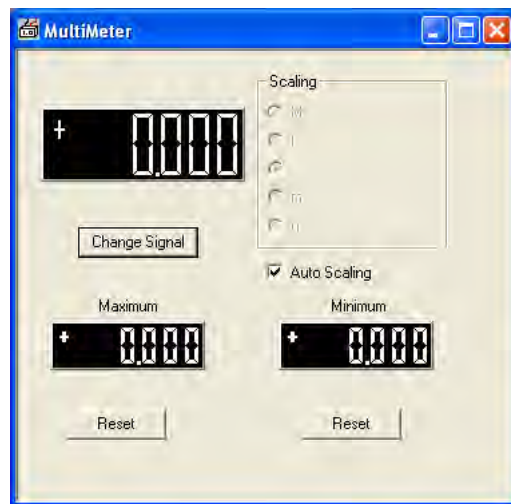
Multimeter

The Multimeter allows you to monitor a multitude of signal types including positions, velocities, torques, and voltages. In addition, a resettable counter keeps track of the minimum and maximum values found. Scaling is selected in the option select field on the right side, or you may choose Auto Scaling to automatically scale the units for you.

You must be connected to a drive to use the multimeter.

To open the multimeter, do one of the following:

- Select Tools > Multimeter on the menu bar.
- Click on the multimeter  icon on the tool bar.



Multimeter Window

To see a list of available signals for the multimeter, see [“Signal Definitions” on page 129](#).



Note

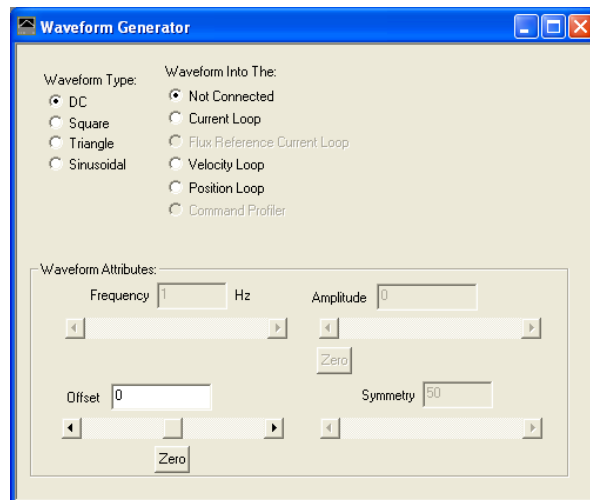
The multimeter samples signals at a rate of once every 250 ms or four times per second. If you want to measure a faster signal, use the Digital Scope.

Waveform Generator

The Waveform Generator is used to generate an internal signal during drive tuning and other procedures. With this waveform generator, the need for external signal sources during tuning is eliminated. The *Units* select option allows you to choose between using load units or motor units as defined in the User Units window.

To open the Waveform Generator, do one of the following:

- Select Tools > Waveform Generator on the menu bar.
- Click the waveform  icon on the tool bar.



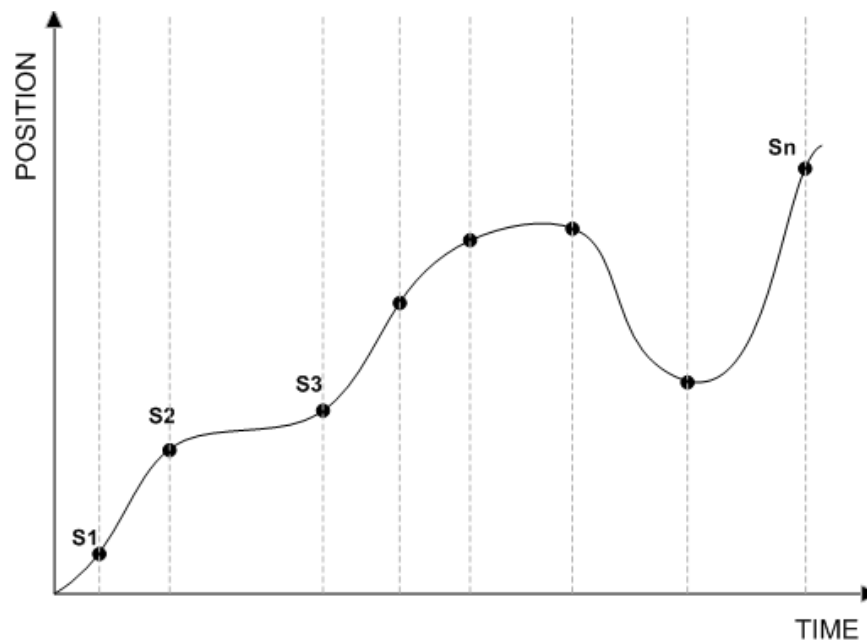
Waveform Generator Window

- **Waveform Type:** Select a DC (constant), square wave, triangle wave, or sinusoidal waveform. The sinusoidal waveform option is not available when waveform generator is connected to the position loop.
- **Waveform Into The:** Select the destination for the waveform signal. Not Connected means the waveform signal will not be used. Command Profiler means the command signal will be limited as defined in the *Command Profiler* Window.
- **Frequency:** Select the frequency of the waveform signal. This becomes inactive when "DC" is selected for the waveform type.
- **Amplitude:** Corresponds to the amplitude of the waveform signal (equivalent to half of the peak-to-peak value). Disabled in case a DC waveform is selected.
- **Offset:** Adds an offset to the selected waveform. If a DC waveform is selected, the offset corresponds to the DC signal amplitude.
- **Symmetry:** Corresponds to the duty cycle or symmetry of the waveform signal. This becomes inactive when DC is selected for the waveform type.

PVT Generator

Typically, you use Point-Velocity-Time (PVT) to stream motion data between multiple axes for coordinated motion. Arbitrary position and velocity profiles can be executed on each axis. A PVT command contains the position, velocity, and time information of the motion profile's segment end points. The servo amplifier performs a third order interpolation between segment end points. This results in a kind of partial trajectory generation where both host controller and servo amplifier generate a specific portion of the overall move profile trajectory. The host controller calculates position and velocity of intermittent points on the overall trajectory, while the servo amplifier interpolates between these intermittent points to ensure smooth motion. The actual position loop is closed within the amplifier. This reduces the amount of commands that need to be sent from host controller to amplifier, which is critical in distributed control systems. The number of segments and the time duration of each segment need to be selected based upon required accuracy and network bandwidth.

Suppose the motor is at rest and the values $P1$, $V1$, and $T1$ are entered in the buffer to represent a PVT point $S1 = (P1, V1, T1)$. If the profile is executed, the drive will attempt to move the motor a distance of $P1$ in $T1$ seconds with a final velocity of $V1$. The path of motion is calculated by using the difference between the initial and the target position and velocity points, and running them through a third order equation to produce a smooth motion profile. The figure below shows an example which involves multiple PVT points $S1, S2, S3, \dots, S_n$ and displays how smooth motion between these points can be produced.



PVT Plot



Note

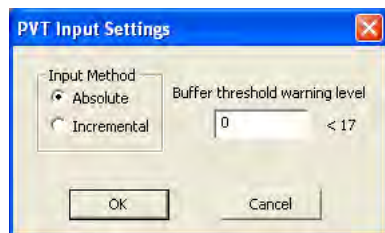
The Position-Velocity-Time (PVT) generator is available after you enable the position loop and set PVT as the command source.

Command Source Settings

Before entering PVT points, you will need to select whether you are using incremental or absolute position.

- Incremental position means each new position value is added to or subtracted from the last position value entered.
- Absolute means each new position value is defined with respect to zero position.

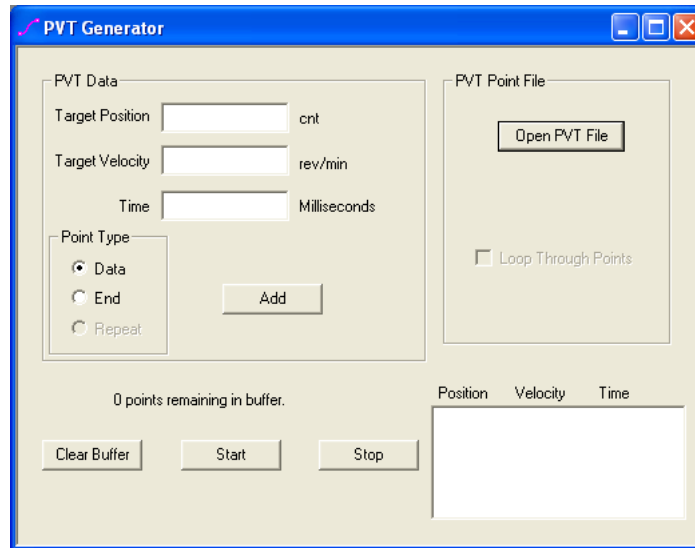
You can select between the two data entry types from within the Command Source window by selecting the ellipses  button next to PVT. This opens the PVT Input Settings window as shown below. For details on the PVT Input Settings window, see "PVT" under [“Event Manager” on page 48](#)



PVT Generator Window

To open the PVT generator, do one of the following:

- Select Tools > PVT Generator on the menu bar.
- Click on the PVT  icon on the tool bar.



PVT Generator Window

The PVT Generator is a graphical user interface for quickly and easily getting started with PVT motion profiles. Up to 16 PVT points can be placed directly into the buffer or, alternatively, a file can be generated for executing a PVT motion profile multiple times.

Entering PVT Points

Two methods for entering PVT points into the buffer are offered through the PVT Generator window.

- Manually, under PVT Data on the left, enter data.
- Automatically, under PVT Point File on the right, open a file with data.

For both methods, position and velocity are specified in user units (see User Units) whereas time is always in milliseconds. Furthermore, velocity is specified on an absolute basis whereas time is specified on an incremental basis with the largest allowable increment being 65535 milliseconds. As described above, position may be either incremental or absolute.

CAN standard supports a time step up to and including 255 milliseconds.

Choose a method for entering PVT points:

Manually adding PVT points

1. Type the three factors that create a PVT point: position, velocity and time.
2. Click Add to move the PVT point to the buffer.
3. This can be repeated a total of 16 times until the PVT buffer is full.
4. Press Start to execute all the PVT points in the buffer.

Using a file to add PVT points You can place the PVT points in a text file and load that data into the buffer. There is no limit to the number of PVT points you can place in the PVT file. These files are useful if you want to repeat a desired sequence several times or save the data for future use.

1. To get started, select the Open PVT File button.
2. Navigate to your PVT file (make sure it has a *.pvt extension).
3. The file name is displayed below the Open PVT File button.
4. Select the Loop Though Points checkbox to continuously loop though the PVT points.
5. Press the Stop button when done.

How To Construct A PVT Points File

A PVT file can be constructed using any simple-text editor (such as Microsoft® NotePad). Each line in the file represents a PVT point by specifying position, velocity, and time separated by semicolons.

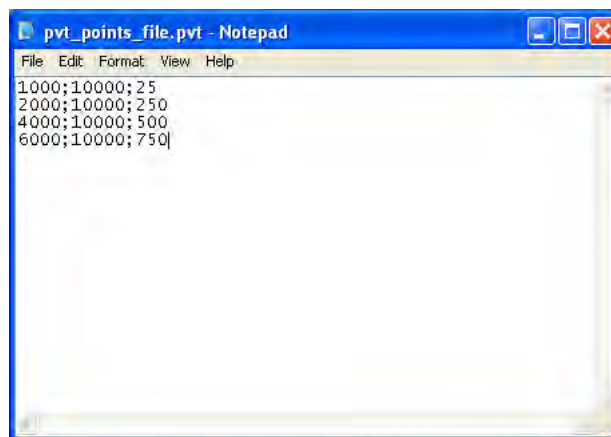
An example of a PVT file with correct formatting, named `pvt_points_file.pvt`, is shown below. Stop points can be used in a PVT file to stop executing PVT points until the Start button is pressed. A

Specify a stop point Simply insert a PVT point with the same position as the previous PVT point but with zero specified for both velocity and time. Stop points can only be entered after a PVT point which specifies zero velocity. So, for example, a stop point could be inserted at the end of `pvt_points_file.pvt` by first adding a PVT point which sets zero velocity, such as `6000;0;1000`, and then specifying the PVT stop point as `6000;0;0`.



Note

A stop point differs from the Stop button in that the Stop button completely stops motion and then clears the buffer. You cannot continue a motion profile once the Stop button is pressed.



PVT Points File

When first saving a PVT file, be sure to replace the default *.txt extension with *.pvt when specifying the file name. Also, if using the *Loop Through Points* option with a PVT file, be sure that the first PVT point in the file can follow logically after the last point in the PVT file. Lastly, when looping through several PVT points with small incremental times, be aware of the fact that the PVT buffer may have time to empty out all of its points before the PVT Generator has time to refill the buffer. Such an event will result in no more than the PVT Buffer Empty status becoming active and is the result of restrictions on the RS232 baud rate used by the software to communicate with the drive.

Before running your PVT file, be sure you are connected at the highest baud rate available, and be sure to minimize the number of applications running in the background. Also close any unnecessary windows (such as multimeter, oscilloscope, and status view), as they will slow down the rate at which your drive receives PVT points, possibly resulting in a PVT buffer error.

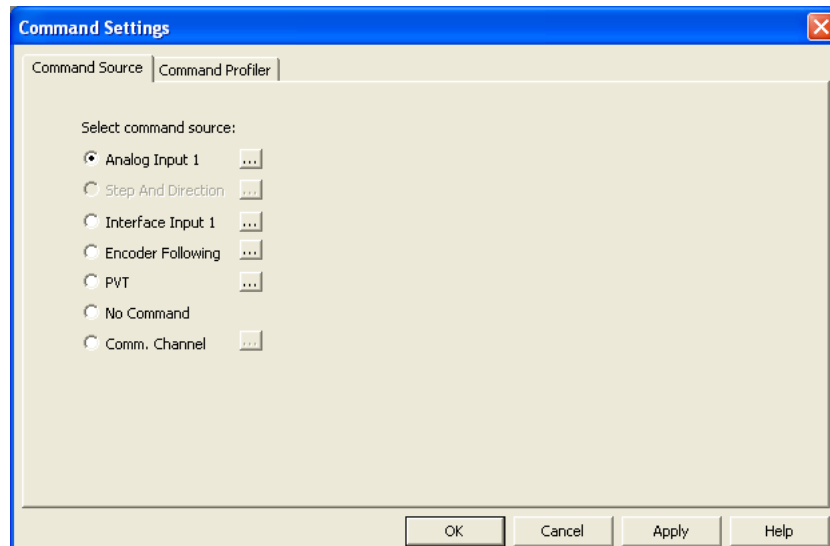
Command Settings



To open the Command Settings, select the Command icon from the Block Diagram; this action opens the Command Settings window.

Command Source Tab

The Command Source selection window allows selection and configuration of the command source. The following command sources are available (depending on operating mode):



Command Settings Window, Command Source tab

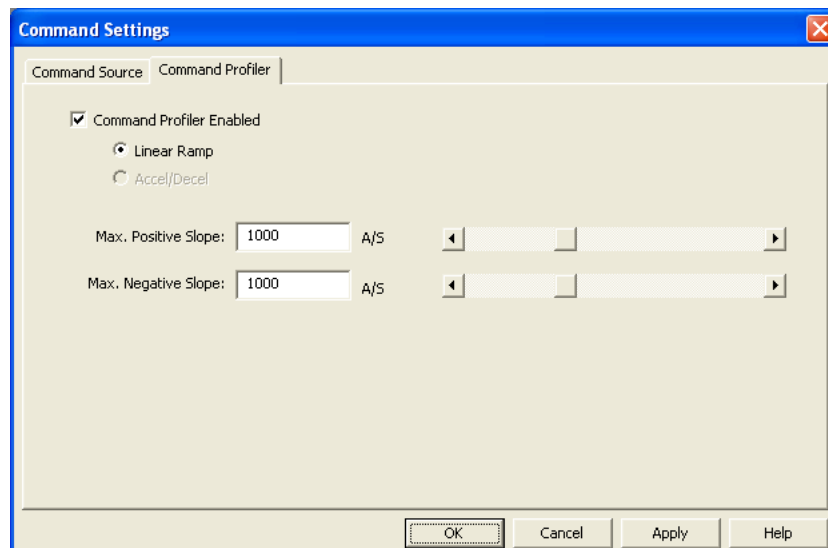
Command Profiler Tab

The Command Profiler allows you to limit the change in input command signal as seen by the drive. The resulting effect is dependant on the operating mode. This is a command *smoother*, not a drive limiter. In other words, it will change how the command is seen by the drive, but if an event occurs which is not affected by the command, the drive will react according to drive limits. For changing drive limits, see Limits & Options.

- **Current Loop Control:** Limits the jerk, or change in commanded torque.
- **Velocity Loop Control:** Limits the acceleration, or change in commanded velocity.
- **Position Loop Control:** Limits the velocity, or change in commanded position. Also can be configured to limit the acceleration.

Command Profiler window changes depending on the mode of operation you are using. See below for the three possible windows.

Current Loop control Limits the change in commanded current.

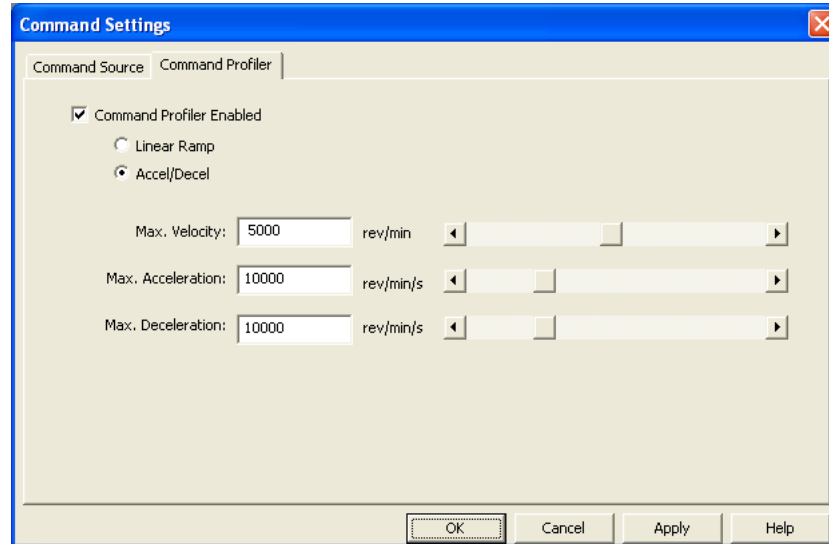


Velocity Loop control Limits the acceleration and deceleration independently for positive and negative velocities.

The image shows a 'Command Settings' dialog box with a blue title bar and a close button (X) in the top right corner. It has two tabs: 'Command Source' and 'Command Profiler', with 'Command Profiler' selected. Inside the dialog, there is a checked checkbox for 'Command Profiler Enabled'. Below it are two radio buttons: 'Linear Ramp' (selected) and 'Accel/Decel'. The 'Positive Velocity' section contains two rows: 'Max. Acceleration' with a text box containing '5000' and a unit dropdown set to 'rev/min/s', and 'Max. Deceleration' with a text box containing '5000' and a unit dropdown set to 'rev/min/s'. The 'Negative Velocity' section also contains two rows: 'Max. Acceleration' with a text box containing '2500' and a unit dropdown set to 'rev/min/s', and 'Max. Deceleration' with a text box containing '2500' and a unit dropdown set to 'rev/min/s'. At the bottom of the dialog are four buttons: 'OK', 'Cancel', 'Apply', and 'Help'.

Position Loop control

- **Linear Ramp:** Limits the velocity, or change in commanded position.
- **Accel/Decel:** Allows acceleration and deceleration limits to be set.



The image shows a 'Command Settings' dialog box with a blue title bar and a close button (X) in the top right corner. It has two tabs: 'Command Source' and 'Command Profiler', with the latter being the active tab. Inside the dialog, there is a checked checkbox labeled 'Command Profiler Enabled'. Below this, there are two radio buttons: 'Linear Ramp' (unselected) and 'Accel/Decel' (selected). Under the 'Accel/Decel' option, there are three rows of controls, each consisting of a text input field, a unit label, and a slider. The first row is 'Max. Velocity: 5000 rev/min', the second is 'Max. Acceleration: 10000 rev/min/s', and the third is 'Max. Deceleration: 10000 rev/min/s'. At the bottom of the dialog, there are four buttons: 'OK', 'Cancel', 'Apply', and 'Help'.

Signal Definitions

The following tables show all of the signals that can be measured using the Oscilloscope and Multimeter. These signals may also be used as analog outputs in compatible drives.

Current measurements

Value	Definition
Current Target	This is the commanded torque-producing current. Current limit settings are ignored.
Current Demand	The commanded torque-producing current, after current limits have been applied. This value is zero when the drive is inhibited.
Current Measured	The actual measured torque-producing current being delivered to the motor. Ideally, this value should be as close as possible to the demand current.
Id - Target	This represents the flux producing stator current in an AC induction motor. Id should equal zero when using a permanent magnet motor.
Id - Demand	This represents the flux producing stator current in an AC induction motor. Id should equal zero when using a permanent magnet motor.
Id - Measured	This represents the flux producing stator current in an AC induction motor. Id should equal zero when using a permanent magnet motor.
Current Phase A	The measured current in motor phase A. The sum of all three phases should add up to zero.
Current Phase B	The measured current in motor phase B. The sum of all three phases should add up to zero.
Flux Ref. Current Target	The commanded flux reference current ignoring limits. The flux reference current is the current induced in the rotor of an AC induction motor.
Flux Ref. Current Demand	The commanded flux reference current, after limits have been applied. The flux reference current is the current induced in the rotor of an AC induction motor.
Flux Ref. Current Measured	The measured flux reference current. The flux reference current is the current induced in the rotor of an AC induction motor.
Flux Ref. Current Error	The difference between the flux reference current target and the flux reference current measured.

For Iq and Id, “I” represents the peak of the current sin wave for an individual phase in a three phase motor.

Depending on the drive type, motor type, and motor settings, some of the signals may not be available.

Velocity measurements

Value	Definition
Velocity Target	This is the commanded velocity ignoring velocity limit settings.
Velocity Demand	The commanded velocity, after velocity limits have been applied. This value is zero when the drive is inhibited.
Velocity Feedback	The velocity as measured by the velocity feedback device (before filtering)
Velocity Measured	The velocity as measured by the velocity feedback device (after filtering)
Velocity Error	The difference between the motor's target velocity and measured velocity.
Primary Feedback Velocity	The velocity as measured by the primary feedback device (before filtering).

Position measurements

Value	Definition
Position Measured	The position as measured by the position feedback device.
Position Target	This is the commanded position ignoring position limit settings.
Position Demand	The commanded position, after position limits have been applied.
Position Error	The difference between the motor's target position and measured position.
Auxiliary Input	The position value measured from the drive's auxiliary inputs.
Primary Feedback Position	The position as measured by the primary feedback device (before filtering).
Auxiliary Feedback Position	The position as measured by the auxiliary feedback device (before filtering).

Commutation

Value	Definition
Sync Error	The error between the actual number of encoder counts compared to the expected number of encoder counts as entered in the Motor page. Values will vary depending on Hall or Index synchronization.
Hall State	The decimal equivalent of the binary combination of the three hall states where Hall A is bit 1 and Hall C is bit 3. (5V = 1, 0V = 0)
Phase Angle	The present number of degrees of the rotor inside one electrical cycle. Also may be called Electrical Angle.
Sync. Capture	The encoder count captured at the Synchronization edge. This will vary depending on the Sync edge chosen from autocommutation (Hall or Index edge).
Stator Angle	The present number of degrees of the stator inside one electrical cycle. This value is equal to the phase angle plus the slip angle.
Encoder Sine	The voltage present on the Sine input pin of a Sine/Cosine encoder drive.
Encoder Cosine	The voltage present on the Cosine input pin of a Sine/Cosine encoder drive.
Encoder SinCos	The value of $\text{Sin}^2 + \text{Cos}^2$ on a Sine/Cosine encoder drive. This represents the encoder health. Ideally, this value should equal 1.
Encoder Fault Word 1	This is word 1 of the fault reported by the encoder when using an absolute encoder with serial feedback.
Encoder Fault Word 2	This is word 2 of the fault reported by the encoder when using an absolute encoder with serial feedback.
Encoder Fault Word 3	This is word 3 of the fault reported by the encoder when using an absolute encoder with serial feedback.

Voltage

Value	Definition
Analog Output	The present voltage applied to the analog output.
DC Bus Voltage	The present voltage applied to the high voltage input of the drive.
Voltage Phase A	The voltage, with respect to DC bus ground, applied to motor phase A.
Voltage Phase B	The voltage, with respect to DC bus ground, applied to motor phase B.
Voltage Phase C	The voltage, with respect to DC bus ground, applied to motor phase C.
Analog Input	The voltage, with respect to signal ground, applied to the analog input.

Command profiler

Value	Definition
Command Profiler Input	The commanded signal input to the Command Profiler. When the Command Profiler is enabled, all commands pass through it first for profiling.

Temperature

Value	Definition
Motor Temp.	The present temperature of the motor read and scaled from the appropriate analog inputs.

Torque

Value	Definition
Motor Torque Measured	The torque applied by the motor. This value is calculated from measured current, as delivered to the motor from the drive, and other user supplied parameters in the Motor Data window.

Drive

Value	Definition
Drive Position	The drive position as measured by the primary feedback device. No position is measured when Hall sensors are used as the only primary feedback device. Always measured in units of counts.
Drive Velocity	The drive velocity as measured by the primary feedback device. No velocity is measured when Hall sensors are used as the only primary feedback device. Always measured in units of counts.

Commanded input value

Value	Definition
Commanded Input	The decimal value read from the interface input.

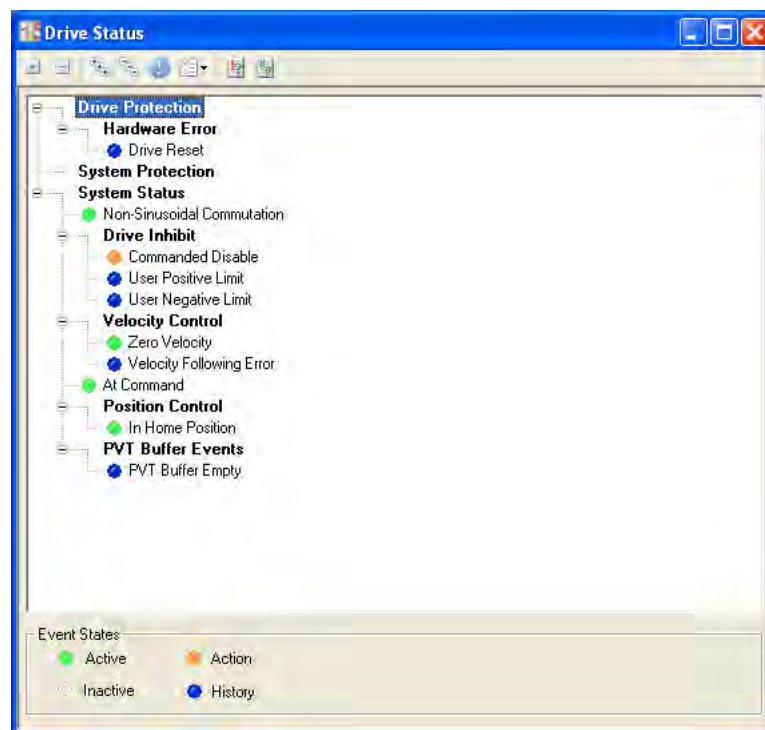
Deadband Input

Value	Definition
Deadband Input	The commanded input before deadband is utilized. Measured in units of current, velocity, or position depending on configuration.

Drive Status

Open the Drive Status window by either:

- Selecting View > Status on the menu bar.
- Clicking on the Drive Status button in the Block diagram.



Status Window

The Drive Status window shows data in three categories:

- Drive protection
- System protection
- System Status

The toolbar across the top of the Drive Status window provides viewing options for the event states in the window.

Icon	Name	Description
	Expand	Show the sub-categories beneath the selected category.
	Collapse	Hide the sub-categories beneath the selected category.
	Expand All	Show all sub-categories.
	Collapse All	Hide all sub-categories.
	Reset Events	Clear the Drive Status window of any history events.
	Options	Select whether Inactive or History events are shown.
	View Critical Event Activity	Bring up the Critical Event Activity window, containing a list of the faults that occurred and the times at which they occurred. This info can be exported to a text file.
	View Event Counter	Bring up the Event Counter, containing a list of all faults and events and the number of times they have occurred. This info can be exported to a text file.

Drive Status Event descriptions

Icon	Name	Description
	Active	An event that is active but not assigned to an action. This includes events assigned to No Action in the Event Manager window and pure status events that cannot be assigned an action.
	Action	An event that is active and assigned to an action. An action either inhibits motion partially or disables motion completely according to the action assigned in the Event Manager window.
	History	An event which is not presently active, but was active at some point after the last time the drive was powered on or the last time the Reset Events button was used.
	Inactive	An event that is not presently active, and has not been active since after the last time the drive was powered on or the last time the Reset Events button was used.

Fault Activity

This function consists of the *Critical Event Activity* window and the *Event Counter*. Both allow you to export the information to text format for easy handling.

Open the Critical Event Activity window by either:

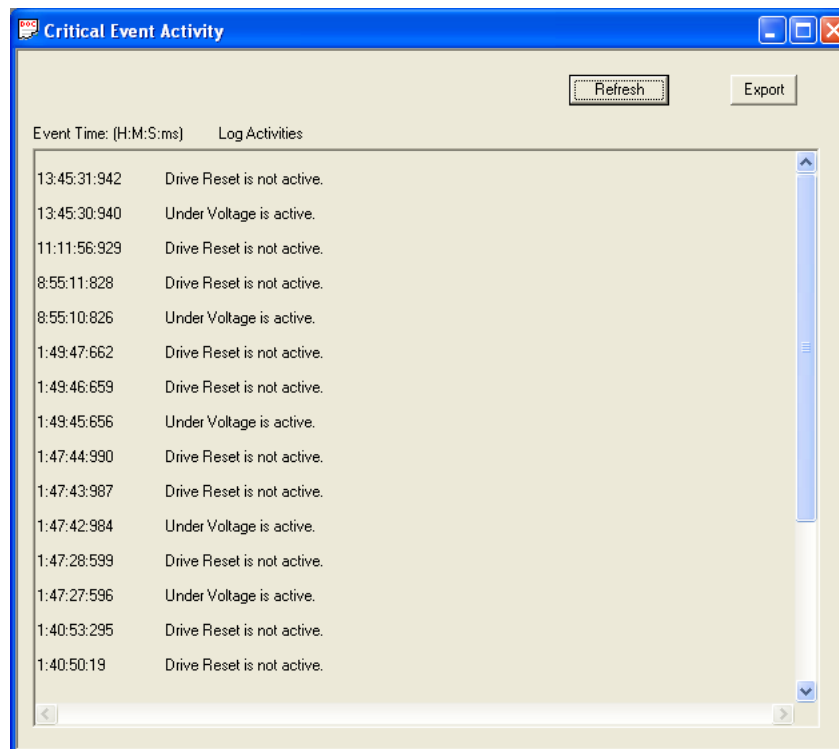
- Selecting View > Event Logs > Critical Event Activity from the File menu.
- Clicking on the Critical Event Activity button from within the Drive Status window.

Open the Event Counter by either:

- Selecting View > Event Logs > Event Counters from the File menu.
- Clicking on the Event Counter button from within the Drive Status window.

Critical Event Activity

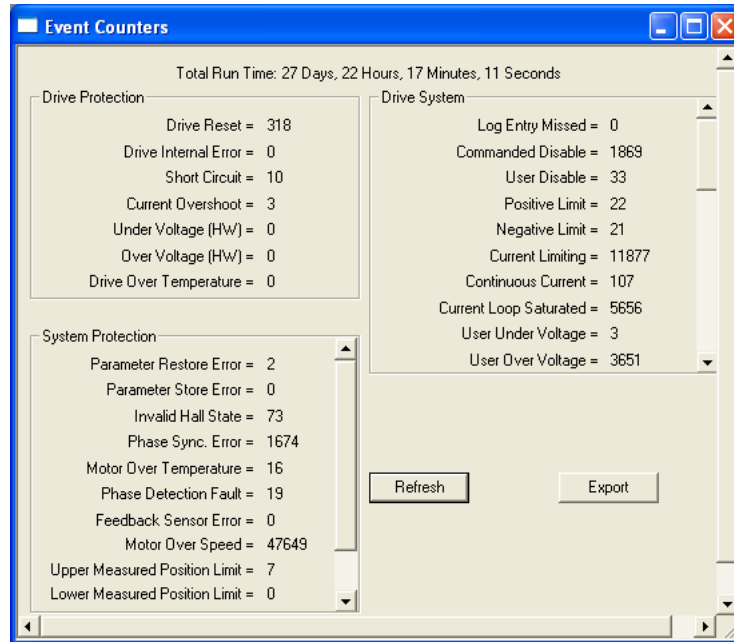
The Critical Event Activity window is a list of drive protection events along with the time they occurred in milliseconds. The critical event activity window contains entries such as Short Circuit and Current Overshoot.



Critical Event Activity Window

Event Counter

Lists the total operating time of the drive and the number of times faults have occurred since the drive has been in operation.



Event Counters Window



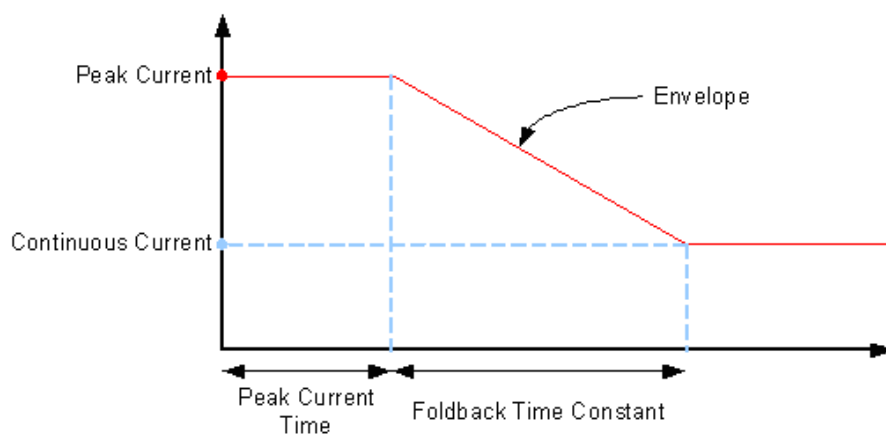
The Event Counter automatically stores to the drive approximately once every nine minutes. If the drive power is shut off within this time frame and a manual store to NVM is not performed, the counter will not be incremented.

B Current Limiting

This topic explains current limiting for digital servo drives. The basic concepts of current limiting are introduced first, followed by a detailed explanation of some underlying formulas.

Understanding the Limit Envelope

Digital drives limit current output according to a well-defined software and hardware current limit envelope. These envelopes consist of Peak Current, for a specified amount of Peak Current Time, followed by a foldback to Continuous Current for an amount of time specified by the Foldback Time Constant.



Foldback & current limit envelope

1. The current limit envelope is shown in red.
2. You use drive setup software to configure the software envelope while the hardware envelope is fixed and defined by drive hardware limitations.
3. The Peak Current Time and Foldback Time Constant of the hardware envelope is the same for all drives, fixed at 2 and 10 seconds, respectively. The current values, however, depend upon the hardware with Peak Current and Continuous Current always equal to the maximum peak and continuous current rating of the drive.

The drive always compares each point on the user specified software envelope against each point on the hardware envelope and takes the lesser of the two to generate the actual application envelope. An example of this, where the hardware envelope almost entirely overrides the software envelope, is shown in Table 1. In this example, a constant 100% peak current command (shown in white) was given to the drive. Because, beyond the first two seconds, the hardware envelope (2 seconds Peak Current Time and 10 second Foldback Time Constant) is less demanding than the software specified envelope (65 second Peak Current Time and 65 second Foldback Time Constant), hardware current limiting is applied.

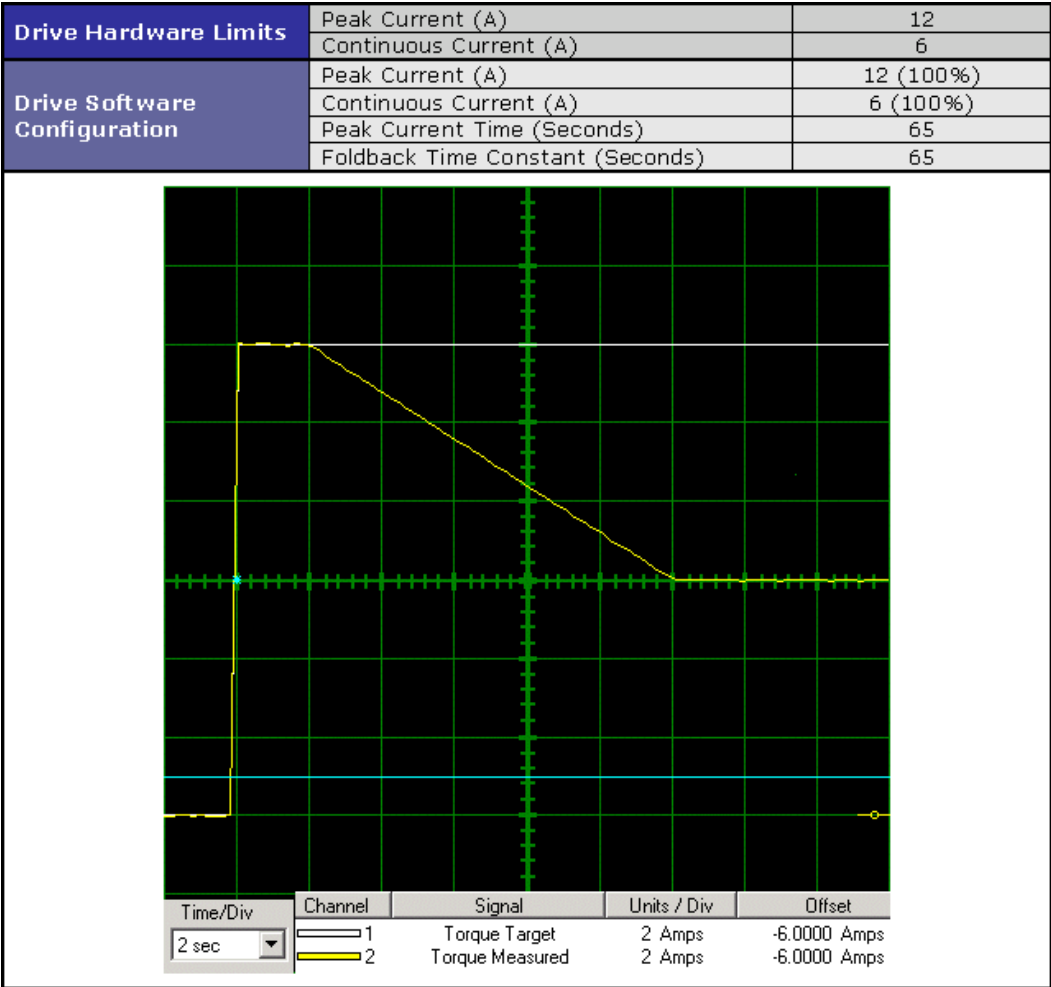


Table 1

In order to have the software envelope entirely hold true, it must be specified such that it remains equal to or within the hardware envelope of the drive. Table 2 shows an example of a software configuration that will hold true in application (i.e. not be overridden by hardware limitations). For convenience, the drive hardware envelope has been superimposed (in red) on the image of Table 2.

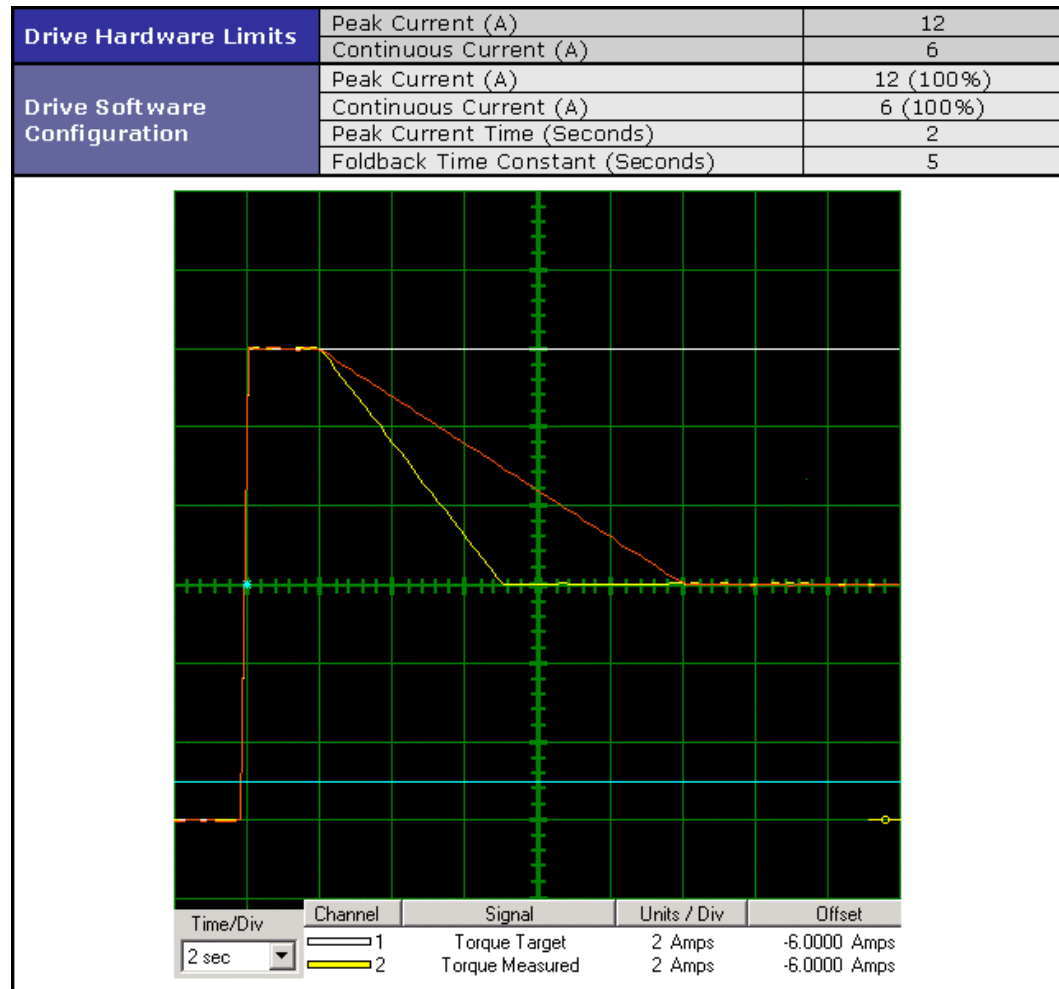


Table 2

On the other hand, Table 3 shows the result of a user configured software envelope that falls outside of the allowed hardware envelope. The image in Table 3 shows how the drive will follow the specified software envelope up until it intersects the hardware envelope.

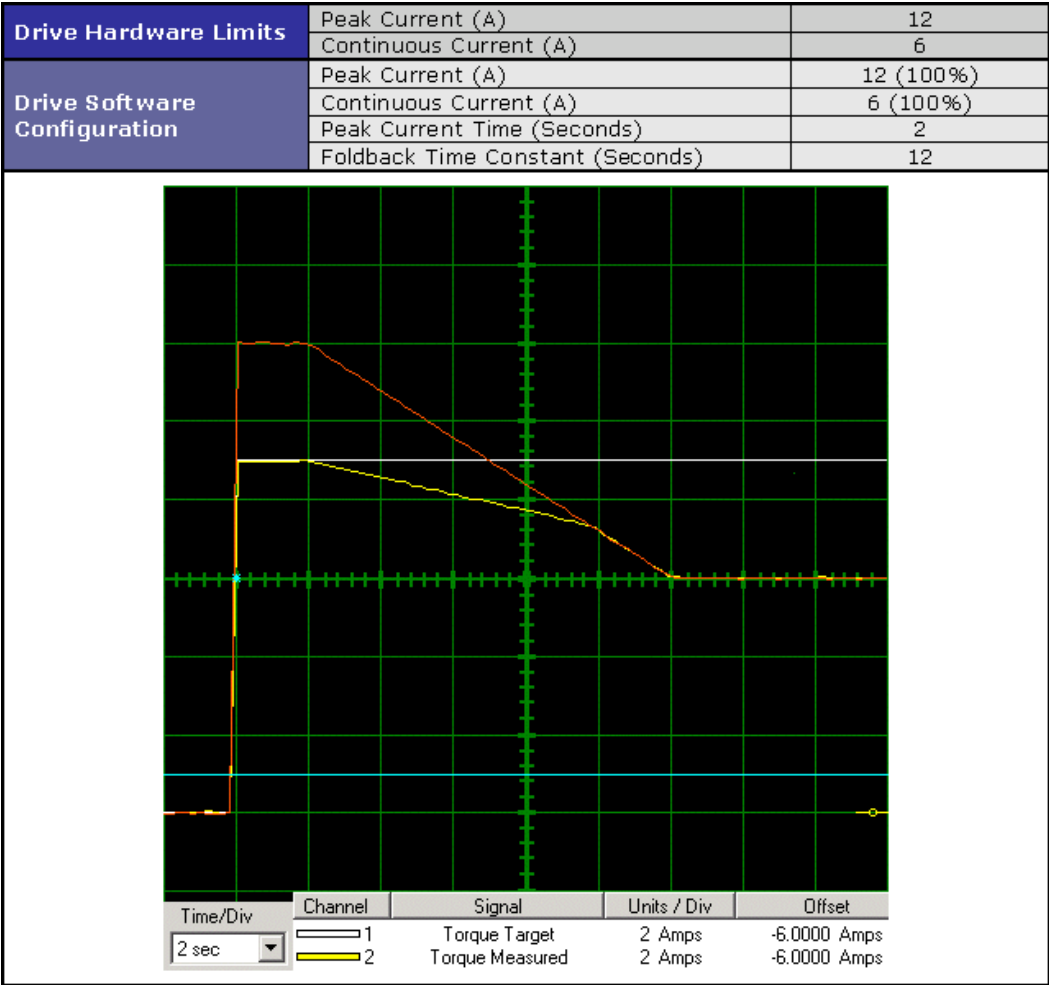


Table 3

Calculating Current Limits

Availability of output current greater than continuous current depends on the level of an internal charge reservoir. Upon power-up, the drive begins with a full reservoir having a charge equal to:

$$Q_P = 2(I_P - I_C)(t_P + t_F)$$

Q_P	=	Peak Reservoir Charge
I_P	=	Peak Current
I_C	=	Continuous Current
t_P	=	Peak Current Time
t_F	=	Foldback Time Constant

A drive with a fully charged reservoir can always output peak current. However, any time the target output current goes above the Continuous Current setting of the drive the reservoir begins to discharge. The rate of discharge is given as:

For $I_T > I_C$,

$$2(I_P - I_C)C/s$$

I_T	=	Target Current (units of amps)
C	=	coulombs
s	=	seconds

Once the reservoir discharges past a threshold necessary to output peak current, the amount of current available to output begins to foldback linearly (assuming hardware limits do not override software limits) from I_P to I_C according to the Foldback Time Constant (t_F).

When the reservoir becomes empty, no more than Continuous Current can be output by the drive. The peak current threshold can be calculated as:

$$Q_{Th} = (Q_P \times t_F) / (t_P + t_F)$$

which is simply the amount of charge that would be depleted over a complete current foldback. The reservoir recharges (up to a maximum of Q_P) anytime the target output current drops below the Continuous Current setting. The rate of charge depends upon how far the target output current is below the Continuous Current as given by:

For $I_T < I_C$,

$$(I_C - I_T)C/s$$

As a result, the reservoir will recharge most rapidly when the target output current is zero (no command or drive inhibited).

Example 1: Foldback Current

What is the output current of a drive enabled in the foldback state ($0 < Q < Q_{Th}$) if the drive is configured according to the parameters in Table 2? Assume that the charge reservoir has been tracked since power-up and is known to be half empty ($Q = Q_p/2$) at the instant it is enabled.

Because current limits are set within hardware limits the current foldback will be linear and easily represented by the first order equation:

For $0 < t < t_x$,

$$I_F = Mt + I_o$$

I_F	=	the foldback current
M	=	the rate of foldback
t	=	is time (drive enabled at $t=0$)
I_o	=	the initial current output

Starting with I_o , the initial amount of current available beyond continuous current will be the maximum difference between peak and continuous current ($I_P - I_C$) weighed against the percentage of charge Q available relative to Q_{Th} . Using I_C as a baseline, this can be formulated as,

For $0 < Q < Q_{Th}$,

$$I_o = (I_P - I_C)Q/Q_{Th} + I_c$$

Taking the drive parameters of Table 2, I_0 is calculated as follows.

$$\begin{aligned} I_0 &= (I_P - I_C) \times [Q_P/2]/[(Q_P \times t_F)/(t_P + t_F)] + I_C \\ &= (I_P - I_C) \times (t_P + t_F)/2t_F + I_C \\ &= (12 - 6) \times (2 + 5)/10 + 6 \\ &= 10.2 \text{ A.} \end{aligned}$$

The rate of foldback can be formulated as

$$M = (I_C - I_P)/(t_F)$$

Again using the parameters of Table 2, this gives $M = (6 - 12)/5 = -1.2$. Lastly, we need to calculate the time at which foldback ends. Knowing that foldback always ends with I_C , we can use the line equation we just generated to calculate t_x by solving for time as follows:

$$\begin{aligned} t_x &= (I_F - I_0)/M \\ &= (6 - 10.2)/-1.2 \\ &= 3.5 \end{aligned}$$

Combining all our results, this yields the formula:

For $0 < t < 3.5$,

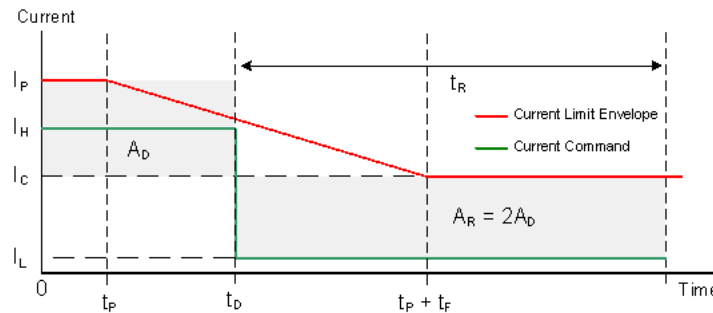
$$I_F = -1.2t + 10.2.$$

Example 2: Peak Current Recovery

If recovery time is the only interest, there's an easy way to calculate the amount of time required to recover maximum peak current. This is shown in the following example.

How long will it take to recover maximum peak current on a drive which, from power-up, is depleted for t_D seconds, where $t_D < t_P + t_F$?

Assume the current command is initially held at a constant current of I_H , where $I_H > I_C$, for t_D seconds and then held constant at I_L , where $I_L < I_C$, for t_R seconds. These parameters are illustrated as:



Depletion of the reservoir always happens at the rate $2(I_P - I_C)$ which means the amount of charge depleted over t_D will be $Q_D = 2(I_P - I_C) \times t_D$. Similarly, for a recharge time of t_R , the charge recovered will be $Q_R = (I_C - I_L) \times t_R$. In order to fully recharge the reservoir, the amount of charge depleted must match the amount recovered such that $Q_R = Q_D$ or $(I_C - I_L)t_R = 2(I_P - I_C)t_D$. The final step is to solve for t_R as shown below.

$$t_R = 2(I_P - I_C)t_D / (I_C - I_L)$$

The concept of peak current recovery can be approached a little differently by matching the area of two squares. This method tends to be more intuitive and is easy to visualize. The previous figure illustrates a typical current limiting envelope (in red) with an example current command (in green) and two square areas marked A_D and A_R . Note that the area of A_D is equal to $(I_P - I_C) \times t_D$ while the area of A_R is equal to $(I_C - I_L) \times t_R$. Now, from Example 2, we know that the charge recovered should match the charge depleted. Given this, we can equate areas as given below:

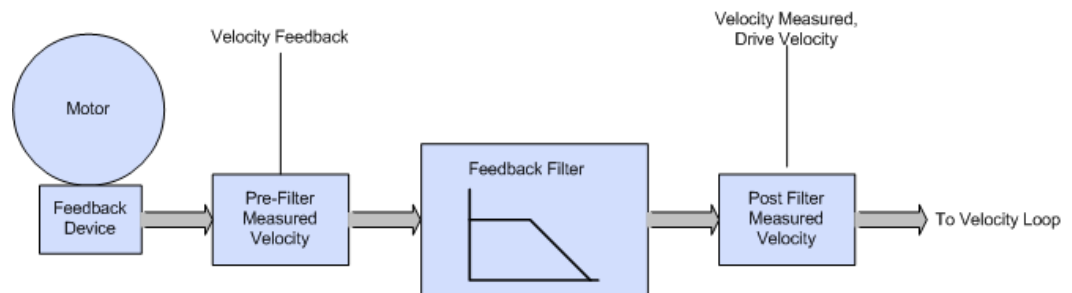
$$\begin{aligned} Q_R &= Q_D \\ (I_C - I_L)t_R &= 2(I_P - I_C)t_D \\ A_R &= 2A_D \end{aligned}$$

Thus, in order to completely recover peak current, the area of the square $(I_C - I_L) \times t_R$ must double the area of the square $(I_P - I_C) \times t_D$.



Filtering Velocity Feedback

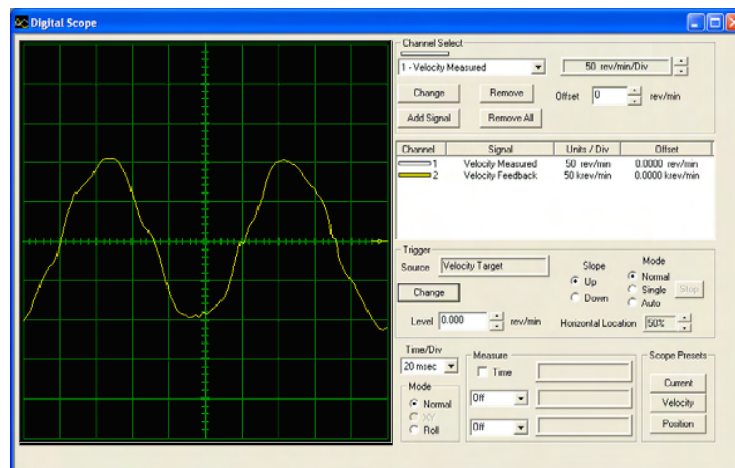
The velocity loop feedback filter uses a single pole low-pass filter to attenuate changes in velocity feedback. This helps to avoid responding to high frequency “spikes” in velocity, resulting in a smoother response to velocity commands.



Effects of the Feedback Filter

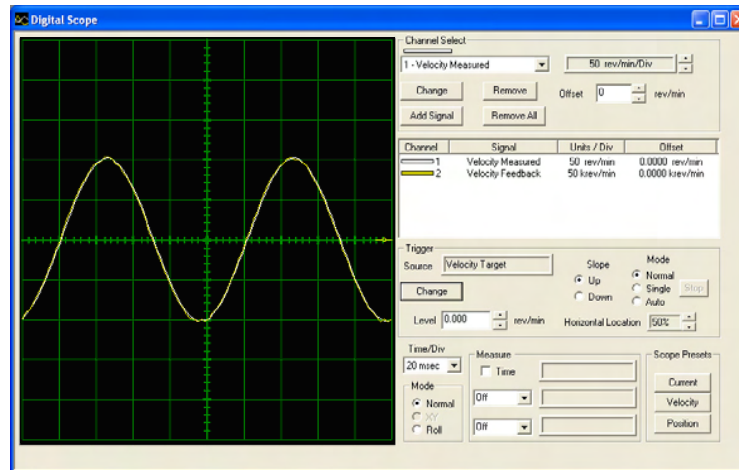
The figures below show how the filter affects measured velocity and, in turn, motor response. For this example, a 10Hz, 100,000-count/sec sine wave is commanded by the drive. This will be considered the worst-case move required for the application. The motor uses a 2000 line encoder, and has a low inertia load coupled to the motor shaft. The current loop and velocity loop gains are tuned aggressively for a fast response.

Cutoff Frequency Set to Infinite



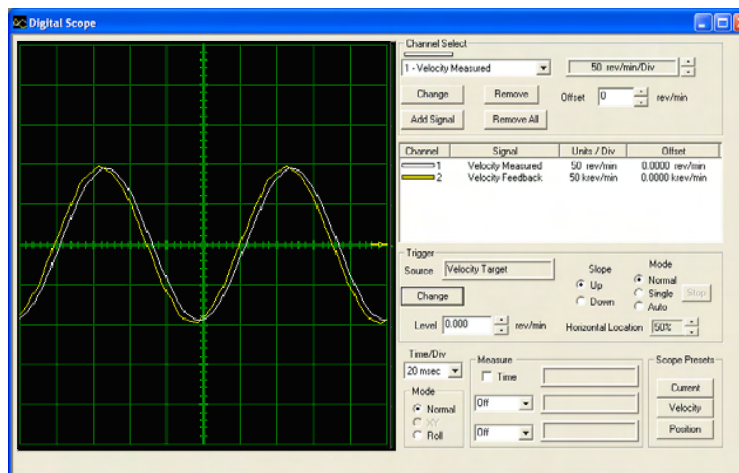
With no feedback filter, the velocity measured and velocity feedback are equal. The velocity loop responds instantly to all measured changes in velocity. The resulting velocity profile is distorted. A loud audible noise is heard from the motor.

Cutoff Frequency Set to 300Hz



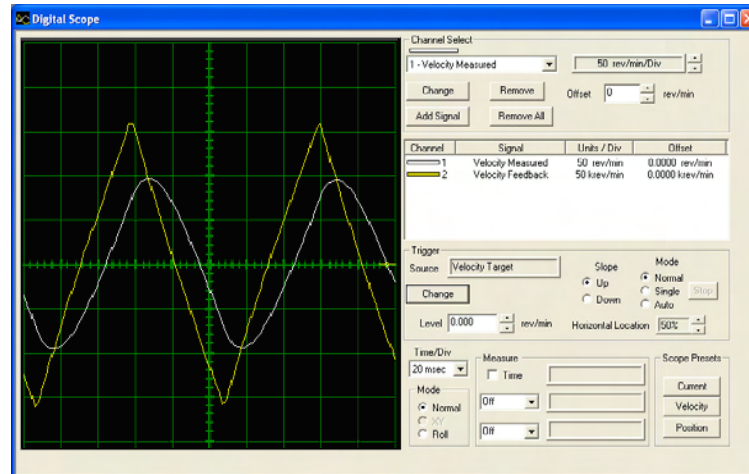
At this level, the audible noise is no longer present and the response is smooth. The two waveforms are nearly identical. This is the optimum setting because it results in no distortion and no phase lag.

Cutoff Frequency Set to 50Hz



At this level, the response is still smooth, but phase lag is apparent as the two waveforms begin to separate.

Cutoff Frequency Set to 10Hz



With the cutoff frequency set to 10Hz, there is an obvious difference between the two waveforms. The response is also noticeable in the motor shaft. The phase lag results in the motor motion becoming unstable.

Conclusion

The velocity loop cutoff frequency filter allows you to tune with higher velocity loop gains, which results in a faster response. Most applications will benefit from a velocity feedback filter cutoff frequency between 50Hz and 1500Hz. Too high of a cutoff frequency may result in audible noise from the motor. Too low of a cutoff frequency will cause significant phase lag and may lead to instability. The cutoff frequency should be adjusted during velocity loop tuning. For the worst-case move, the motor should follow the command smoothly, and there should be little or no phase lag between the velocity feedback and velocity measured traces.



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